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Yamazaki et al.

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(54) **SHEET FEEDING DEVICE AND IMAGE FORMING APPARATUS**

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B65H 3/14 (2006.01)

(52) **U.S. Cl.**
USPC **271/97**; 271/98; 271/96; 271/108

(58) **Field of Classification Search**
USPC 271/108, 97, 98, 96, 94, 12, 104
See application file for complete search history.

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(57) **ABSTRACT**

A sheet feeding device includes drawing and conveying a sheet, applying negative pressure for sheet suction via a suction opening, moving a shutter member between a closing position where the suction opening in an upstream side in a sheet feeding direction is partially closed and an open position where the suction opening is opened, and controlling the shutter member to follow a preceding sheet that is drawn onto the suction conveyance member to move to the downstream side in the feeding direction to close the suction opening, and return to an open position at a predetermined timing to draw the sheets onto the suction conveyance member in a state where an upstream edge of the preceding sheet in the feeding direction and a downstream edge of the subsequent sheet in the feeding direction are overlaid by a predetermined amount.

10 Claims, 11 Drawing Sheets

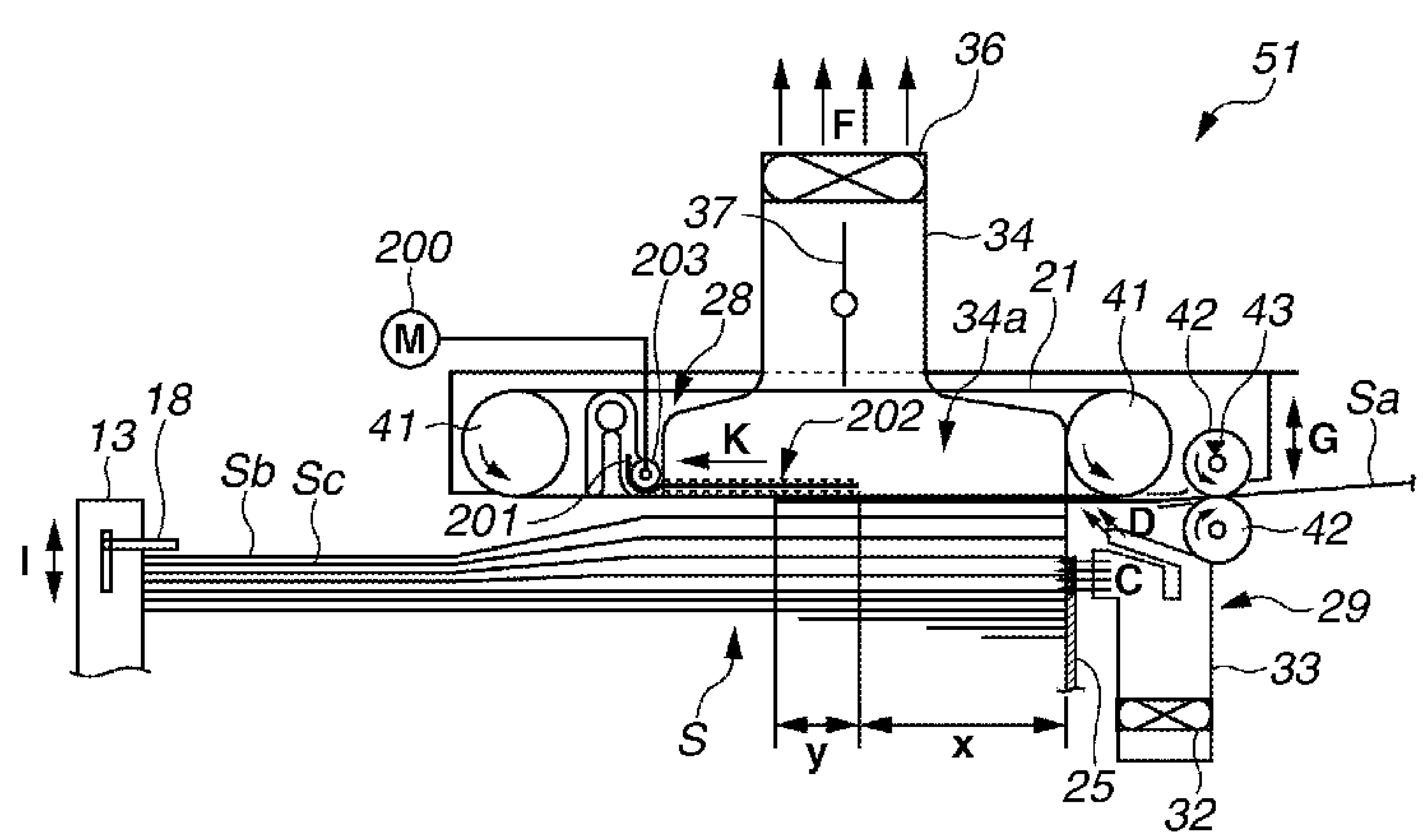
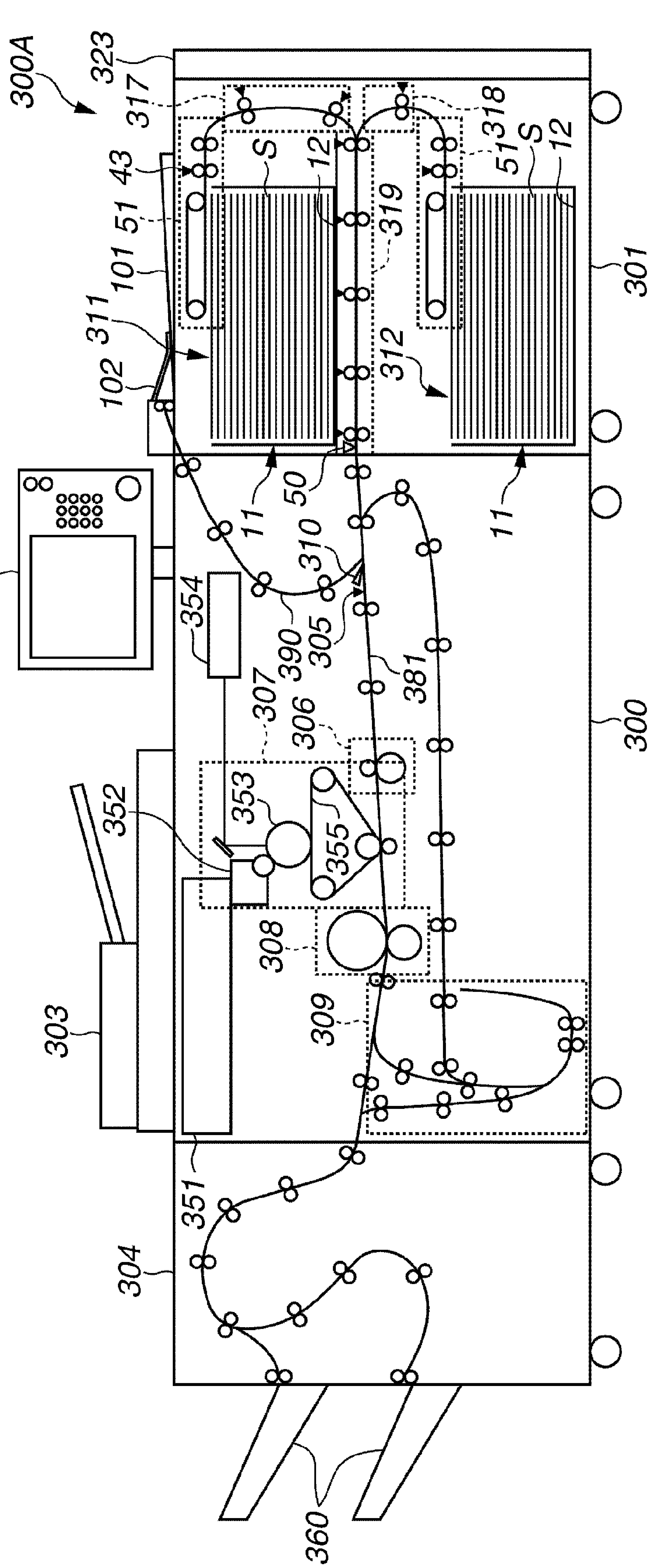


FIG.1


300A
323
317
43
51
101
311
102
S
12
319
318
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301
312
11
50
11
302
310
354
390
305
381
307
306
300
353
352
355
308
309
303
351
304
360

FIG.2

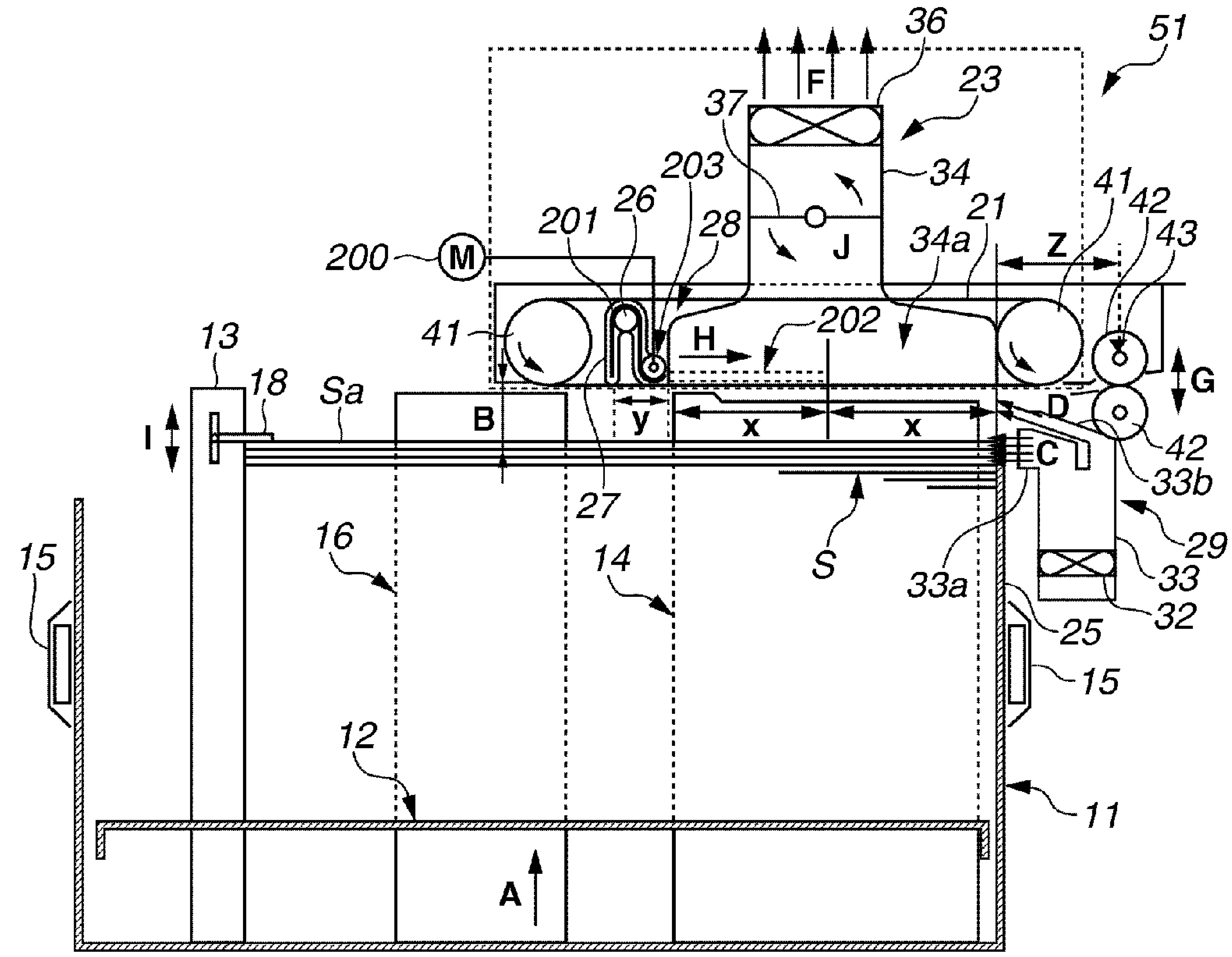

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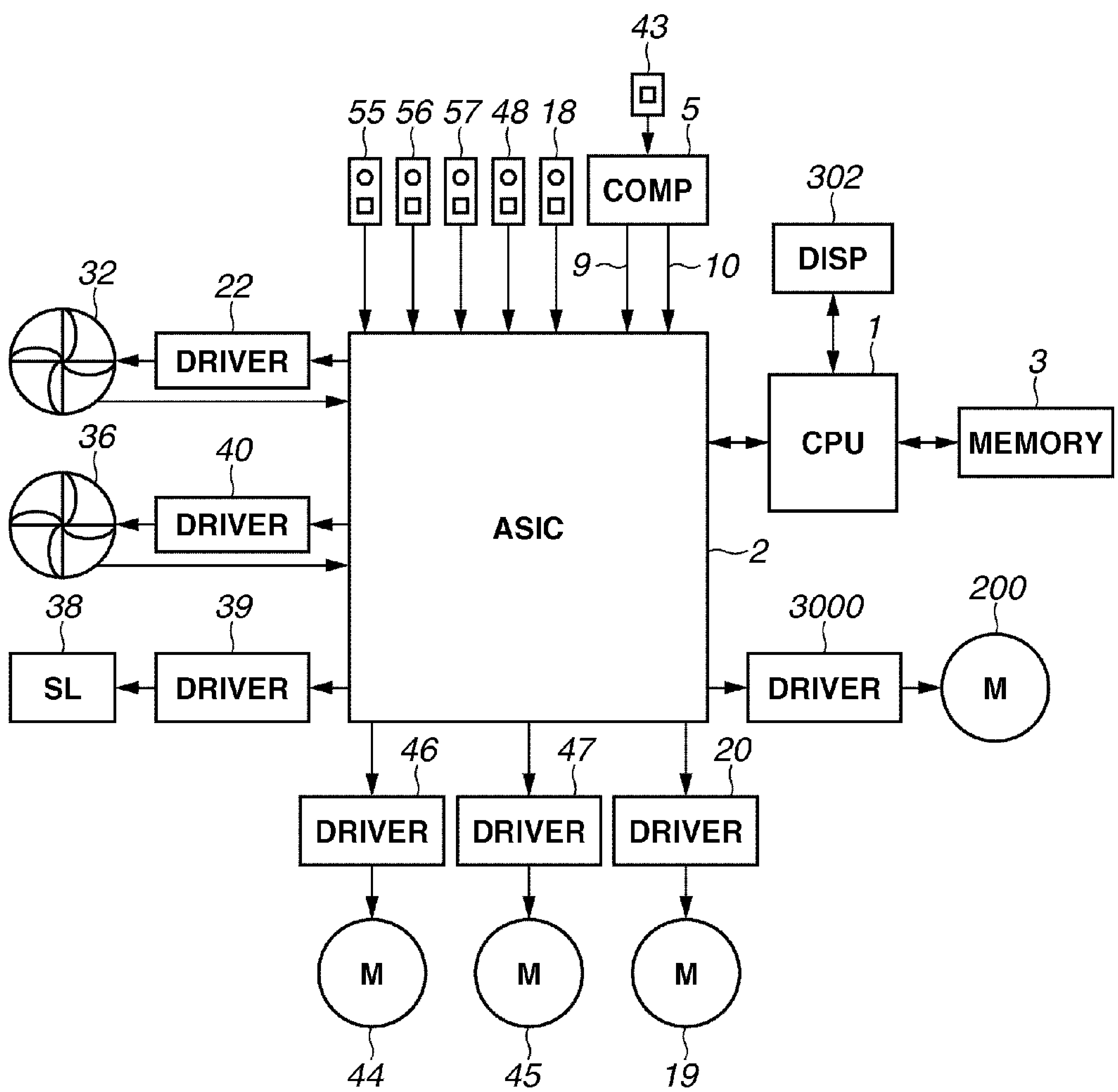
FIG.3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ASIC
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38
39
SL
DRIVER
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DRIVER
DRIVER
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44
45
19

FIG.4A

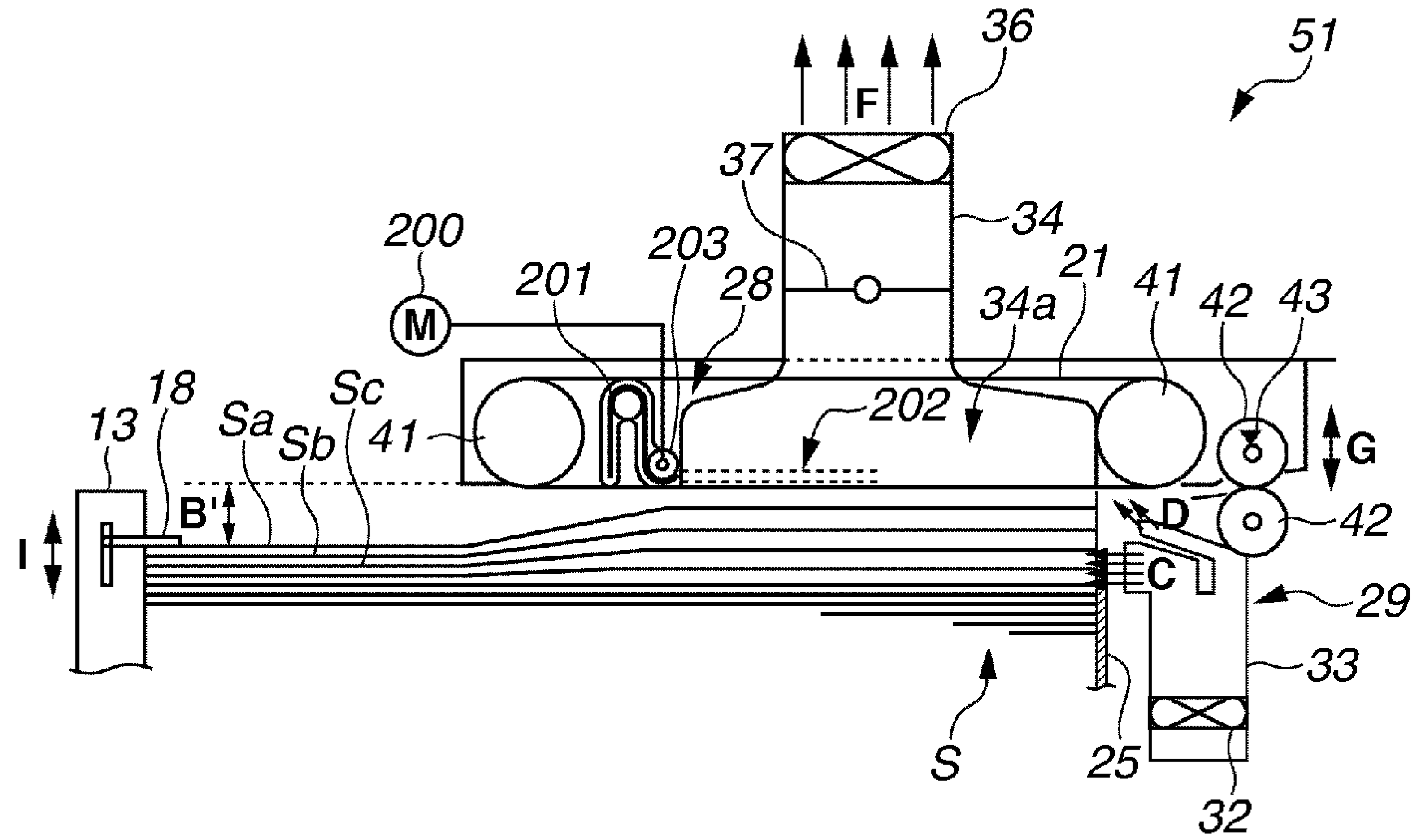
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FIG.4B

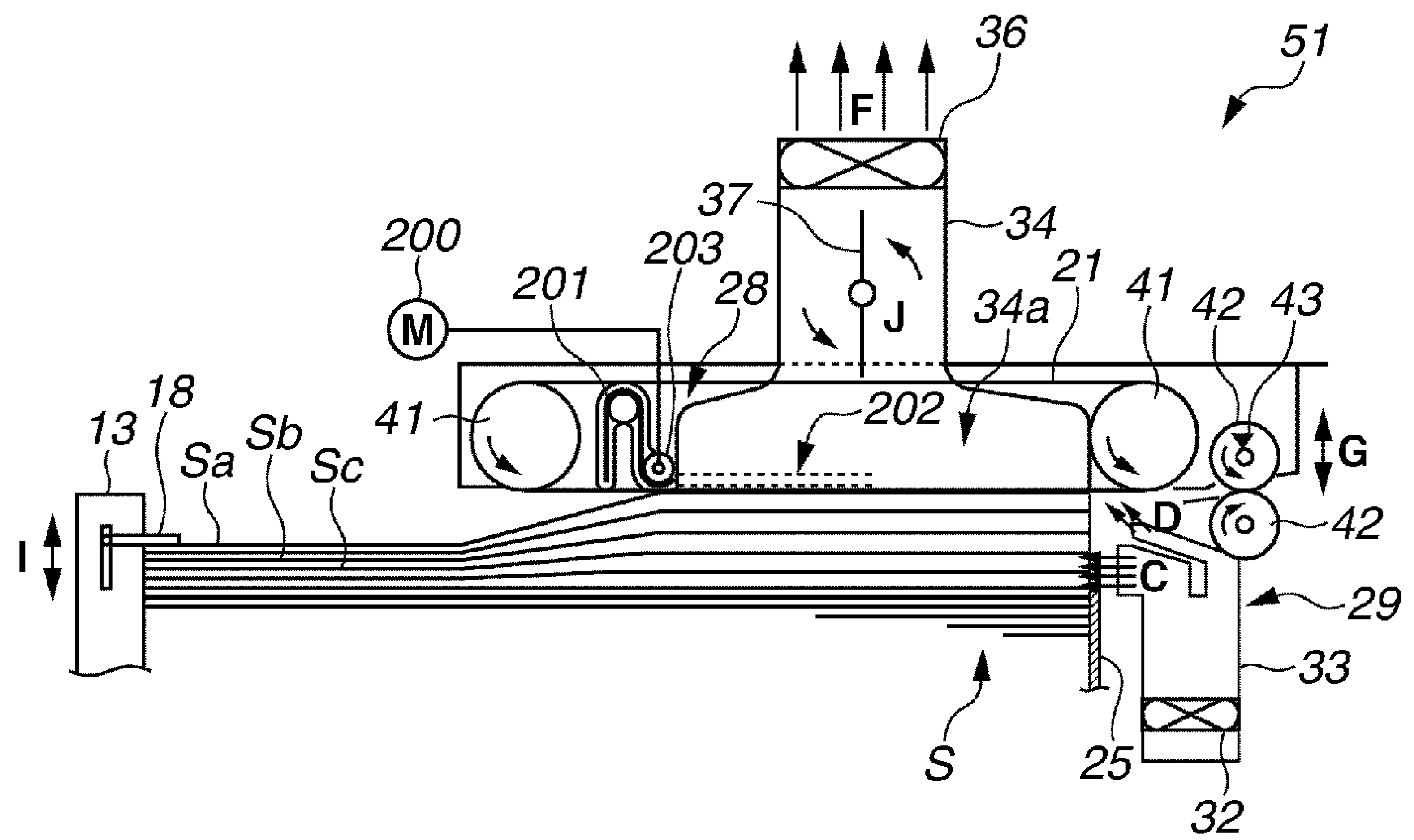
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FIG.5A

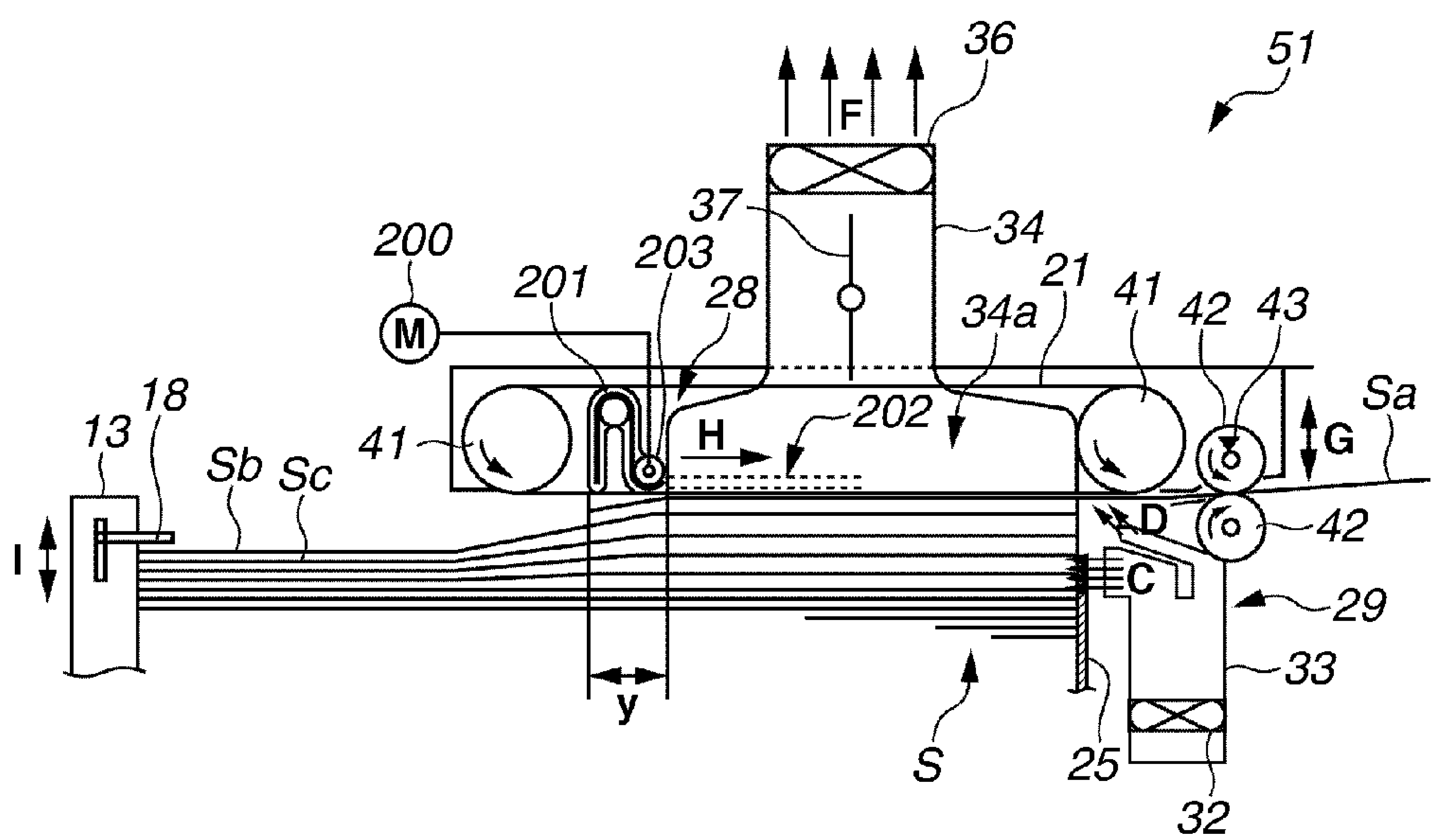
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FIG.5B

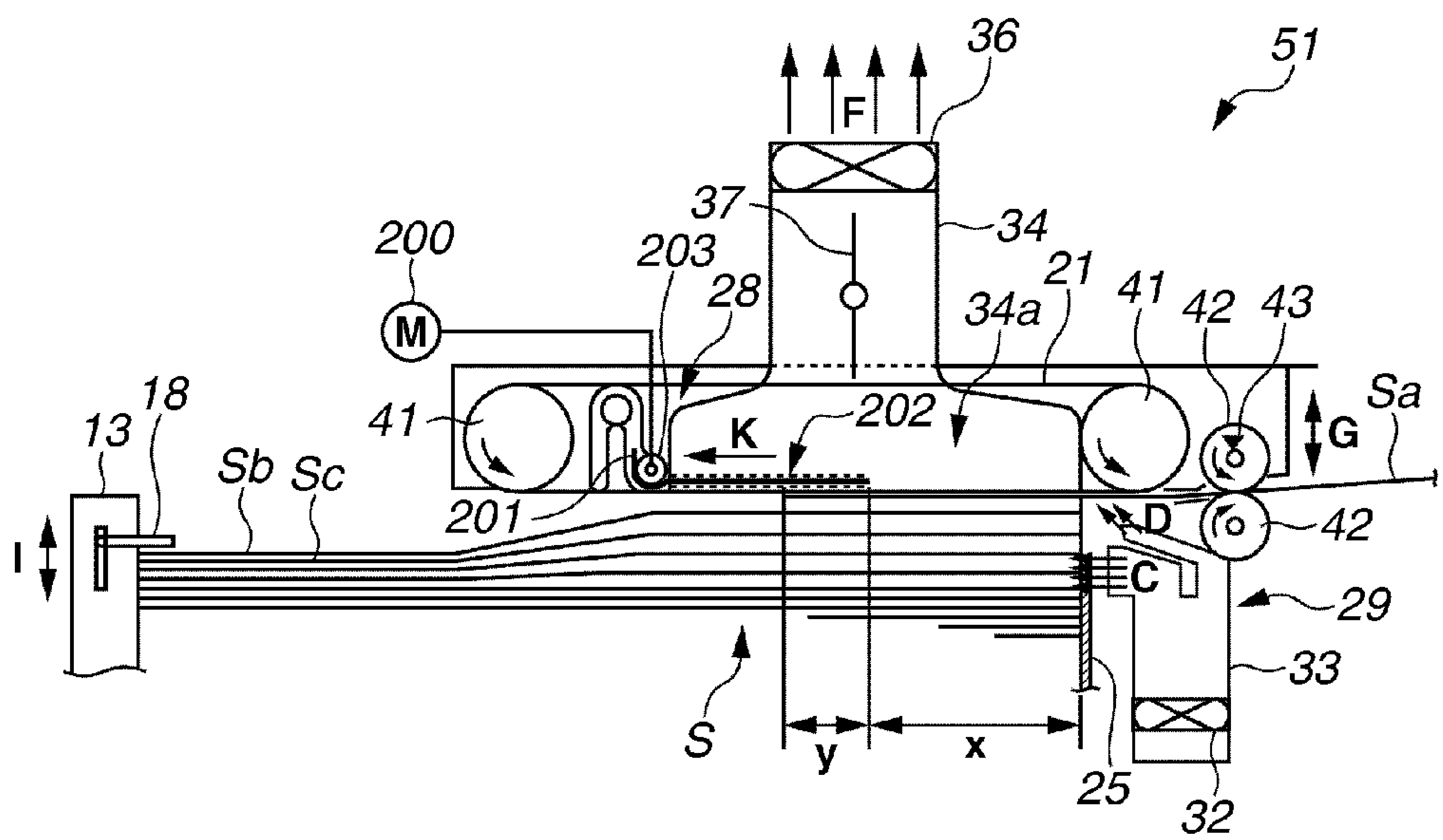
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FIG.6A

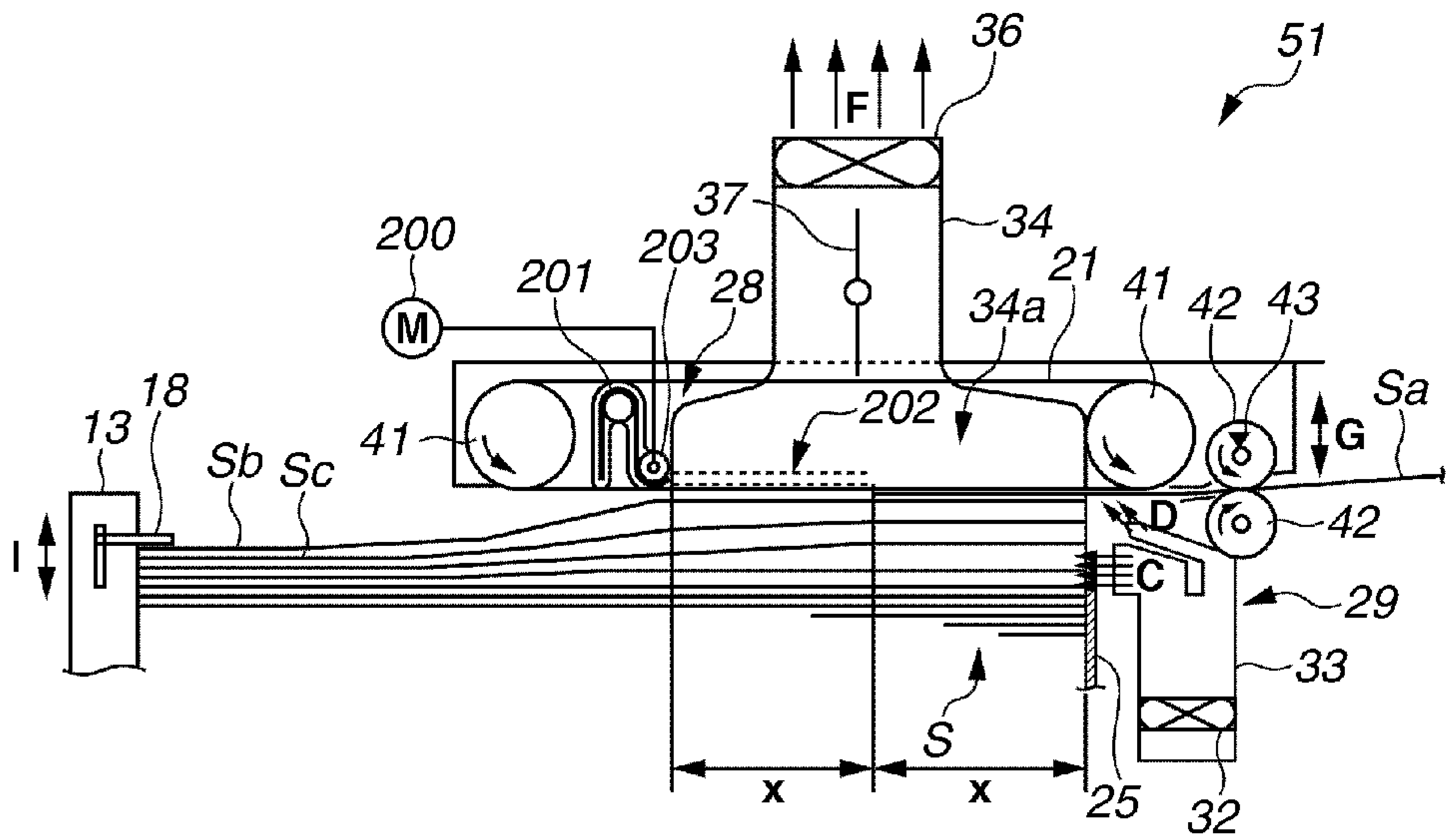
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FIG.6B

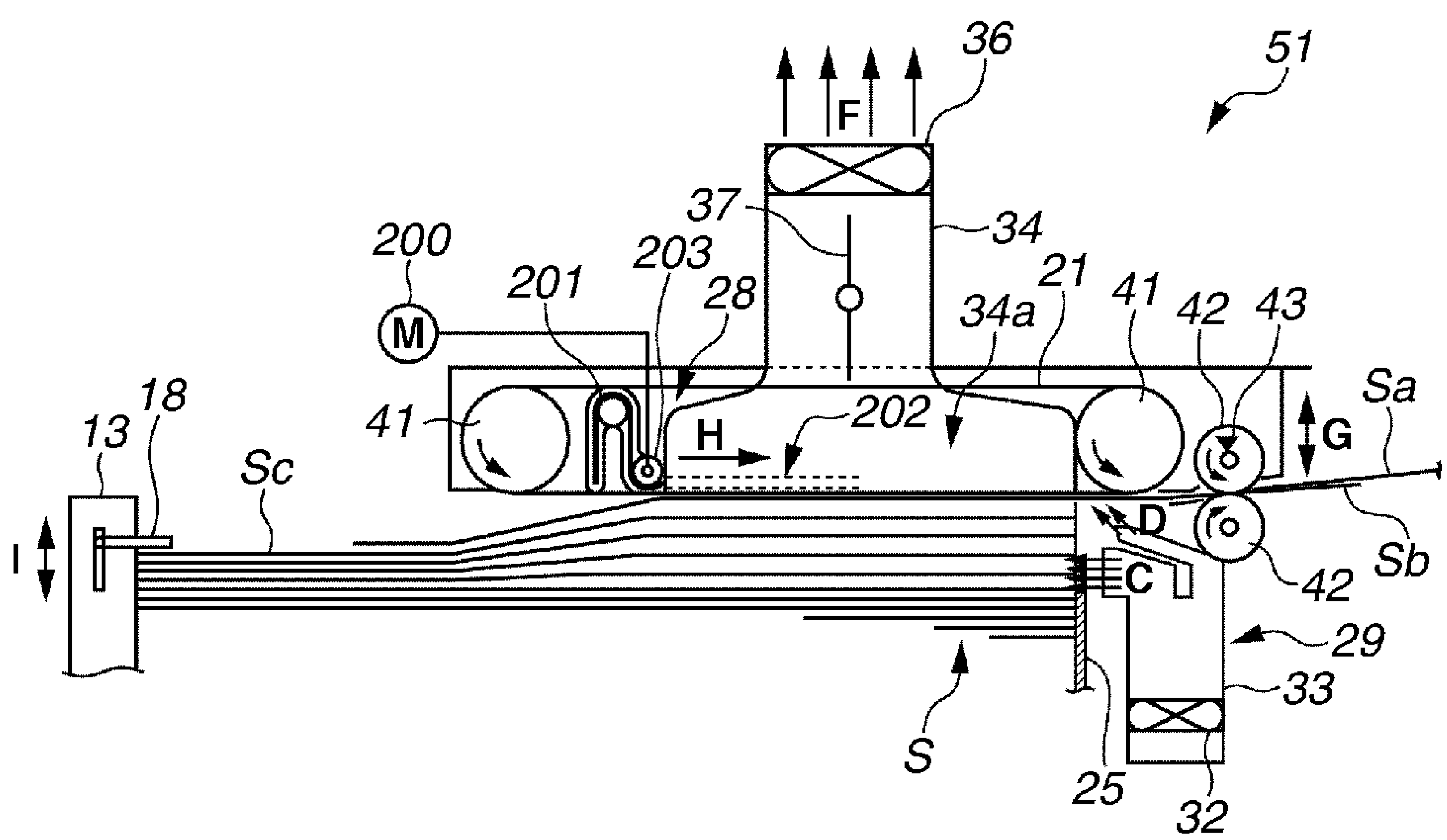
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FIG.6C

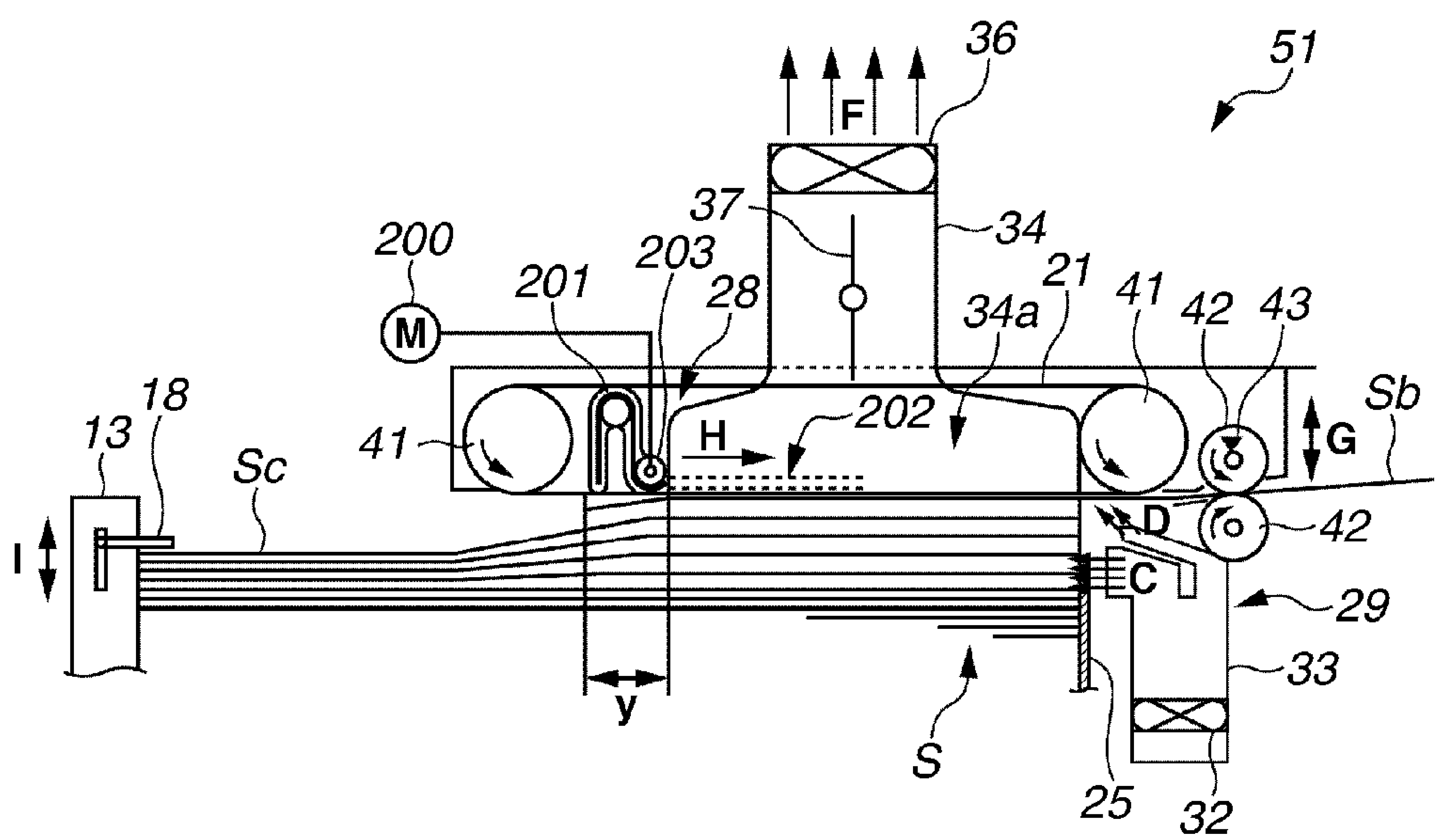

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FIG.7

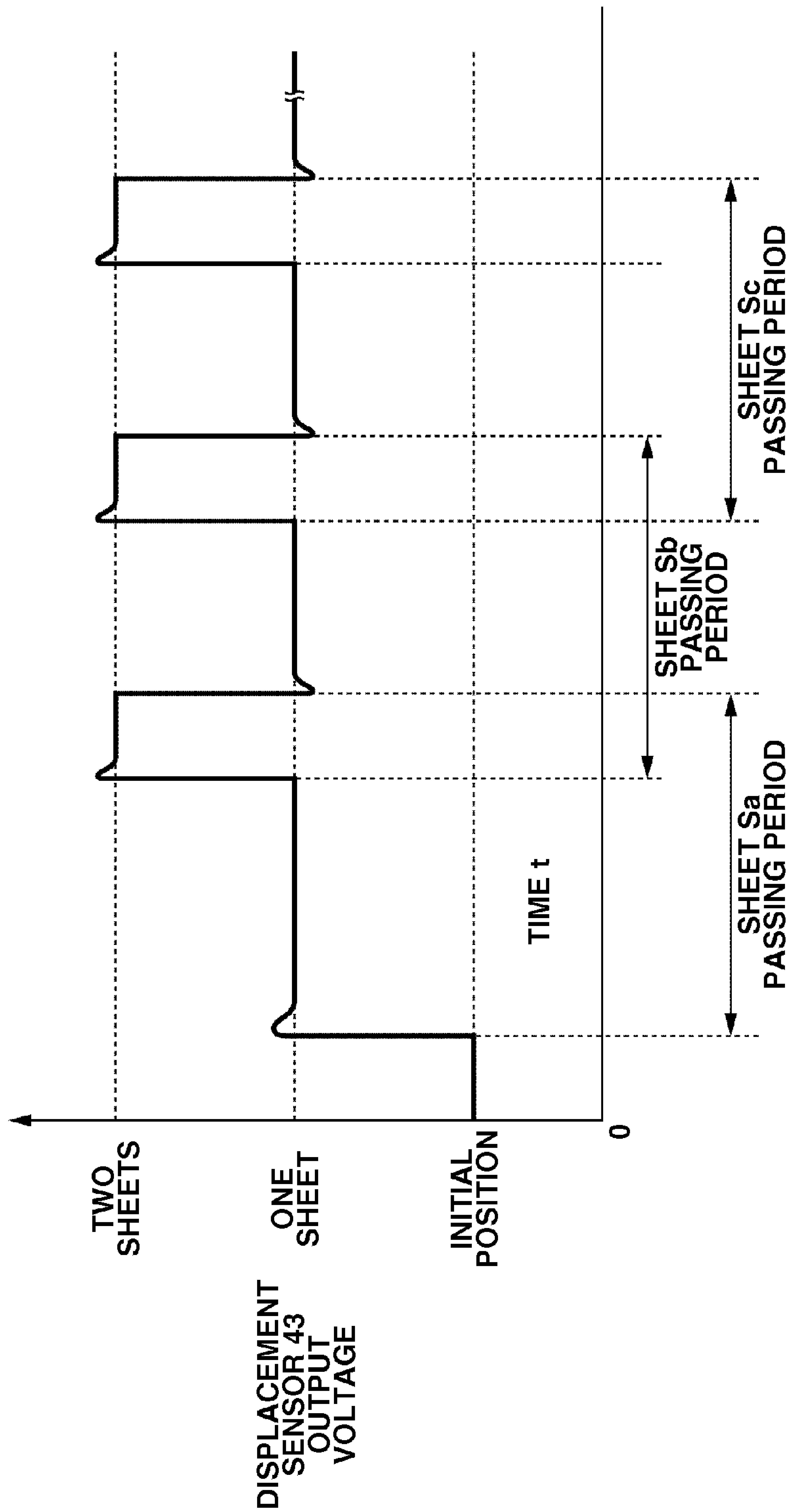

DISPLACEMENT SENSOR 43 OUTPUT VOLTAGE
TWO SHEETS
ONE SHEET
INITIAL POSITION
0
TIME t
SHEET Sa PASSING PERIOD
SHEET Sb PASSING PERIOD
SHEET Sc PASSING PERIOD

FIG.8

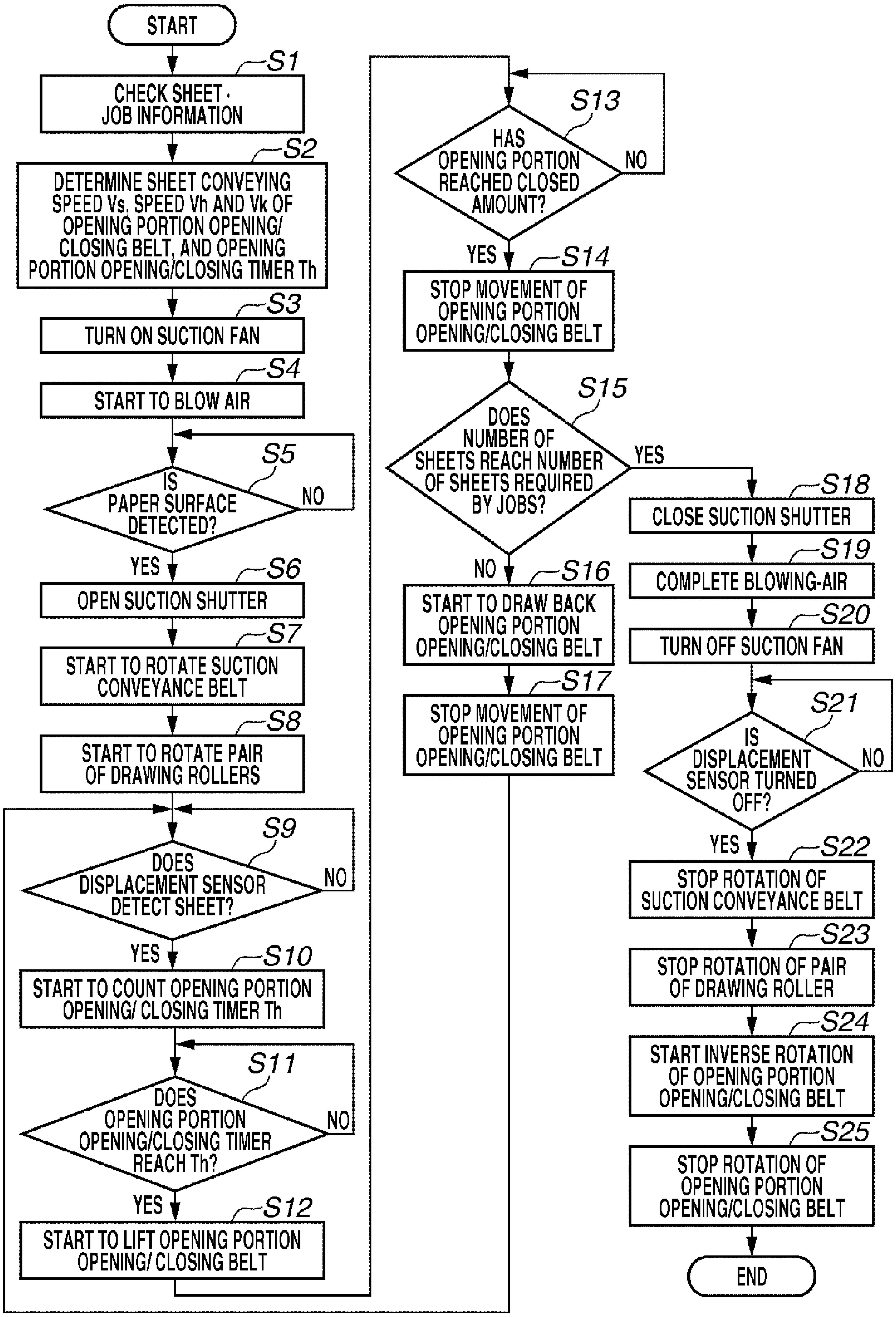

START
S1
CHECK SHEET · JOB INFORMATION
S2
DETERMINE SHEET CONVEYING SPEED Vs, SPEED Vh AND Vk OF OPENING PORTION OPENING/ CLOSING BELT, AND OPENING PORTION OPENING/CLOSING TIMER Th
S3
TURN ON SUCTION FAN
S4
START TO BLOW AIR
S5
IS PAPER SURFACE DETECTED?
NO
YES
S6
OPEN SUCTION SHUTTER
S7
START TO ROTATE SUCTION CONVEYANCE BELT
S8
START TO ROTATE PAIR OF DRAWING ROLLERS
S9
DOES DISPLACEMENT SENSOR DETECT SHEET?
NO
YES
S10
START TO COUNT OPENING PORTION OPENING/ CLOSING TIMER Th
S11
DOES OPENING PORTION OPENING/CLOSING TIMER REACH Th?
NO
YES
S12
START TO LIFT OPENING PORTION OPENING/ CLOSING BELT
S13
HAS OPENING PORTION REACHED CLOSED AMOUNT?
NO
YES
S14
STOP MOVEMENT OF OPENING PORTION OPENING/CLOSING BELT
S15
DOES NUMBER OF SHEETS REACH NUMBER OF SHEETS REQUIRED BY JOBS?
YES
NO
S16
START TO DRAW BACK OPENING PORTION OPENING/CLOSING BELT
S17
STOP MOVEMENT OF OPENING PORTION OPENING/CLOSING BELT
S18
CLOSE SUCTION SHUTTER
S19
COMPLETE BLOWING-AIR
S20
TURN OFF SUCTION FAN
S21
IS DISPLACEMENT SENSOR TURNED OFF?
NO
YES
S22
STOP ROTATION OF SUCTION CONVEYANCE BELT
S23
STOP ROTATION OF PAIR OF DRAWING ROLLER
S24
START INVERSE ROTATION OF OPENING PORTION OPENING/CLOSING BELT
S25
STOP ROTATION OF OPENING PORTION OPENING/CLOSING BELT
END

FIG.9 FIG.9A

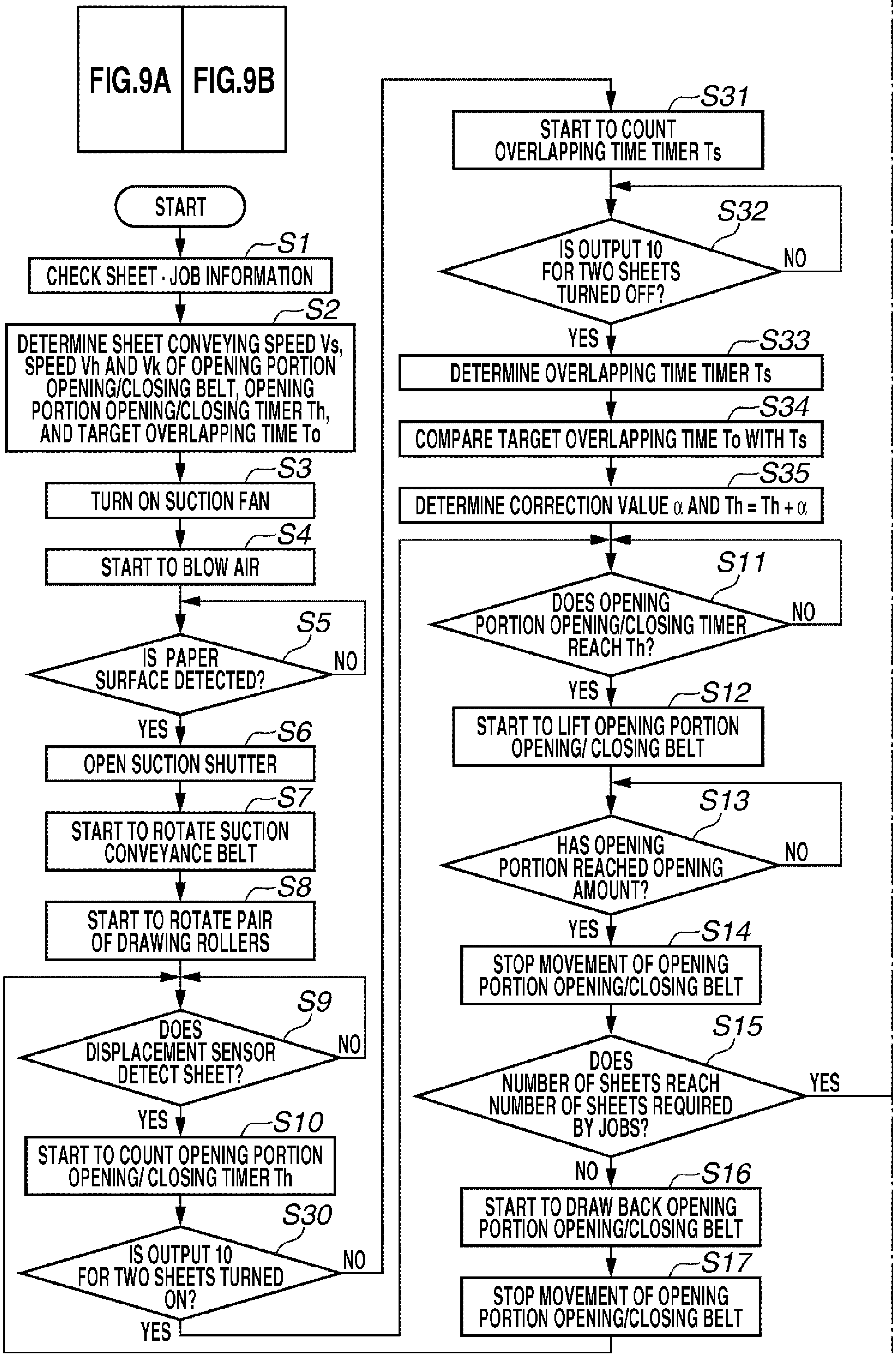
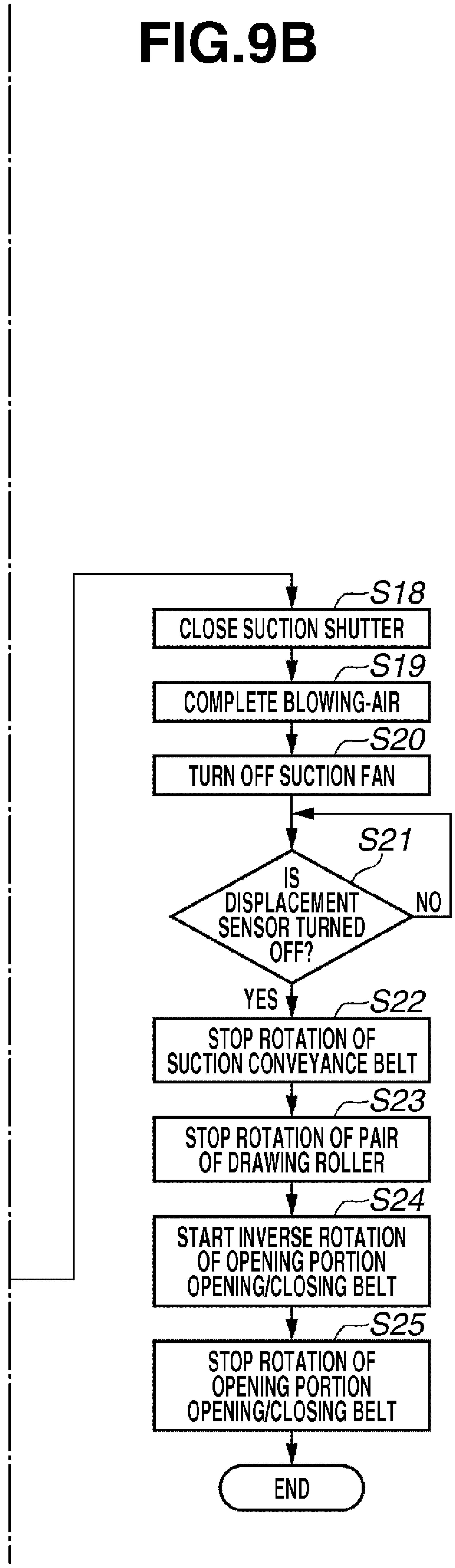


FIG.9A
FIG.9B
START
S1
CHECK SHEET · JOB INFORMATION
S2
DETERMINE SHEET CONVEYING SPEED Vs, SPEED Vh AND Vk OF OPENING PORTION OPENING/CLOSING BELT, OPENING PORTION OPENING/CLOSING TIMER Th, AND TARGET OVERLAPPING TIME To
S3
TURN ON SUCTION FAN
S4
START TO BLOW AIR
S5
IS PAPER SURFACE DETECTED?
NO
YES
S6
OPEN SUCTION SHUTTER
S7
START TO ROTATE SUCTION CONVEYANCE BELT
S8
START TO ROTATE PAIR OF DRAWING ROLLERS
S9
DOES DISPLACEMENT SENSOR DETECT SHEET?
NO
YES
S10
START TO COUNT OPENING PORTION OPENING/ CLOSING TIMER Th
S30
IS OUTPUT 10 FOR TWO SHEETS TURNED ON?
NO
YES
S31
START TO COUNT OVERLAPPING TIME TIMER Ts
S32
IS OUTPUT 10 FOR TWO SHEETS TURNED OFF?
NO
YES
S33
DETERMINE OVERLAPPING TIME TIMER Ts
S34
COMPARE TARGET OVERLAPPING TIME To WITH Ts
S35
DETERMINE CORRECTION VALUE α AND Th = Th + α
S11
DOES OPENING PORTION OPENING/CLOSING TIMER REACH Th?
NO
YES
S12
START TO LIFT OPENING PORTION OPENING/ CLOSING BELT
S13
HAS OPENING PORTION REACHED OPENING AMOUNT?
NO
YES
S14
STOP MOVEMENT OF OPENING PORTION OPENING/CLOSING BELT
S15
DOES NUMBER OF SHEETS REACH NUMBER OF SHEETS REQUIRED BY JOBS?
YES
NO
S16
START TO DRAW BACK OPENING PORTION OPENING/CLOSING BELT
S17
STOP MOVEMENT OF OPENING PORTION OPENING/CLOSING BELT

FIG.9B


S18
CLOSE SUCTION SHUTTER
S19
COMPLETE BLOWING-AIR
S20
TURN OFF SUCTION FAN
S21
IS DISPLACEMENT SENSOR TURNED OFF?
NO
YES
S22
STOP ROTATION OF SUCTION CONVEYANCE BELT
S23
STOP ROTATION OF PAIR OF DRAWING ROLLER
S24
START INVERSE ROTATION OF OPENING PORTION OPENING/CLOSING BELT
S25
STOP ROTATION OF OPENING PORTION OPENING/CLOSING BELT
END

SHEET FEEDING DEVICE AND IMAGE FORMING APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

Aspects of the present invention generally relate to a sheet feeding device and an image forming apparatus, and specifically to a device that separates and feeds sheets by blowing an air to the sheets.

2. Description of the Related Art

In the related art, an image forming apparatus, such as a printer or a copying machine, includes a sheet feeding device that feeds sheets one by one loaded in a tray that supports a plurality of sheets. As the sheet feeding device, an air feeding method is known that blows air to an edge of a sheet bundle supported in the tray to float a plurality of sheets while loosening the sheets, and draws the sheet onto a suction conveyance belt disposed at the upper side to feed the sheet one by one. This technology has been discussed in U.S. Pat. No. 7,575,231.

In the meantime, a conveying method is discussed that separately conveys sheets one by one at a predetermined interval by a sheet feeding unit, while partially overlaying the sheets being conveyed. In this conveying method, the sheets are continuously conveyed by a conveyance belt and fallen at the downstream side of the conveyance belt. A delivery belt and a pressing roller are provided in an apparatus employing this conveyance method. The delivery belt receives and further conveys the fallen sheets. The pressing roller presses a leading edge of the sheet which is inclined between the conveyance belt and delivery belt.

In the conveying method that uses these belts, the delivery belt is driven at a sufficiently slower speed than the conveyance belt. Therefore, a sheet is conveyed in a state where a trailing edge of a preceding sheet is hanging on the conveyance while a leading edge thereof is hanging on the delivery belt such that a leading edge of a subsequent sheet is overlaid with the trailing edge of the preceding sheet. This technology is discussed in Japanese Patent Application Laid-Open No. 11-217148.

As described above, since the sheets are conveyed to overlay with each other in a stable state owing to the pressing roller that presses the leading edge of the sheet, it is possible to increase a conveyance amount of sheets in a unit time without increasing a driving speed of the roller or the belt in a conveyance path. Further, by suppressing the driving speed to be low, it is further possible to satisfy a certain performance even when a small size and low speed actuator is used as a driving source. Therefore, it is possible to suppress the increase in the cost, an operation noise, and power consumption to be low even when the actuator is driven at a high speed.

However, when the feeding unit of the air feeding method in the related art and a conveyance unit that conveys sheets to overlay with each other are combined, after separately delivering the sheets one by one from the feeding unit, the conveyance unit conveys sheets in an overlaid state to improve productivity. In this case, in order to improve the productivity by increasing a conveyance amount of the sheets, even though the conveyance amount of sheets is increased by the overlay conveyance in the conveyance unit, a feeding speed in the feeding unit that delivers the sheet to the conveyance unit goes up in proportion to a quantity of production. Therefore this method may not contribute to the lowering of the speed.

If a mechanism which conveys the sheets by the air feeding method while overlaying with each other is provided in the conveyance path, a size of the entire sheet feeding device

becomes larger. Further, in order to perform overlay conveyance, two conveying speeds need to be provided, which may make apparatus control complicated.

SUMMARY OF THE INVENTION

According to aspects of the present invention, a sheet feeding device and an image forming apparatus are capable of reducing a feeding speed without lowering a production quantity of sheets with a simple configuration and improving sheet conveying efficiency while the sheets are fed to overlay with each other by an air feeding method.

According to an aspect of the present invention, a sheet feeding device includes an elevatable tray that supports a sheet, an air blowing unit that blows air toward the sheet supported by the tray to float the sheet, a suction conveyance member that draws and conveys the sheet floated by driving the air blowing unit, a negative pressure generation part that has a suction opening that applies a negative pressure for sheet suction to the suction conveyance member, a shutter member that moves between a closing position where the suction opening in an upstream side in the sheet feeding direction is partially closed and an open position where the suction opening is opened, and a controlling unit that is, in a driving state of the negative pressure generation part, configured to control the shutter member to follow a preceding sheet that is drawn onto the suction conveyance member, to move to a downstream side in the feeding direction to close the suction opening, and return to the open position at a predetermined timing to draw the sheets onto the suction conveyance member in a state where an upstream edge of the preceding sheet in the feeding direction and a downstream edge of the subsequent sheet in the feeding direction are overlaid by a predetermined amount in a driving state of the negative pressure generation part.

Further features and aspects of the present invention will become apparent from the following detailed description of exemplary embodiments with reference to the attached drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated in and constitute a part of the specification, illustrate exemplary embodiments, features, and aspects of the invention and, together with the description, serve to explain the principles of the invention.

FIG. **1** is a schematic configuration view of an image forming apparatus including a sheet feeding device according to an exemplary embodiment of the present invention.

FIG. **2** is a cross-sectional view illustrating a configuration of a second sheet feeding device in a sheet feeding unit of the image forming apparatus.

FIG. **3** is a block diagram illustrating a control system of the sheet feeding device according to the exemplary embodiment of the present invention.

FIGS. **4**A and **4**B are cross-sectional views illustrating a feeding operation of a suction conveyance unit of the sheet feeding device according to the exemplary embodiment of the present invention.

FIGS. **5**A and **5**B are cross-sectional views illustrating a feeding operation of a suction conveyance unit of the sheet feeding device according to the exemplary embodiment of the present invention.

FIGS. **6**A to **6**C are cross-sectional views illustrating a feeding operation of a suction conveyance unit of the sheet feeding device according to the exemplary embodiment of the present invention.

FIG. **7** is a timing chart illustrating an example of a detection waveform from a displacement sensor of the sheet feeding device according to the exemplary embodiment of the present invention.

FIG. **8** is a flowchart illustrating an operation of a sheet feeding device according to a first exemplary embodiment of the present invention.

FIG. **9** is a flowchart illustrating an operation of a sheet feeding device according to a second exemplary embodiment of the present invention.

DESCRIPTION OF THE EMBODIMENTS

Various exemplary embodiments, features, and aspects of the invention will be described in detail below with reference to the drawings.

FIG. **1** is a schematic configuration view of an image forming apparatus including a sheet feeding device according to an exemplary embodiment of the present invention. In FIG. **1**, an image forming apparatus **300**A includes a main body **300** of the image forming apparatus (hereinafter, referred to as main body), a manipulation part **302**, a sheet feeding unit **301**, and a sheet processing device **304**. Processing such as feeding and conveying a sheet, forming an image, or stapling is performed based on a sheet processing setting set in the manipulation part **302** or an external host PC which is not illustrated by a user and image information transmitted from a reader scanner **303** or the external PC.

The sheet feeding unit **301** includes first and second sheet feeding devices **311** and **312** at upper and lower sides. In the sheet feeding devices **311** and **312**, sheet storages **11** and **11** that store a sheet bundle and suction conveyance mechanisms **51** and **51** that feed the sheets stored in the sheet storages **11** and **11** are provided. In this exemplary embodiment, the suction conveyance mechanisms **51** and **51** use an air feeding method and feed the sheet while an endless belt is drawing the sheet at the time of a sheet feeding operation.

Here, the sheet feeding unit **301** sequentially feeds and conveys the sheets in each of the sheet storages **11** and **11** in an overlaid state according to sheet request information from the main body **300**. Further, the sheet feeding unit **301** conveys a leading sheet to a conveyance sensor **50** which is disposed in a transfer part transferring a sheet to the image forming apparatus **300**A. The sheet feeding unit **301** notifies the main body **300** that sheet delivery is ready after the conveyance is completed.

The main body **300** receives the notification that delivery is ready, from the sheet feeding unit **301** and notifies a delivery request to the sheet feeding unit **301**. The sheet feeding unit **301** sequentially conveys the overlaid sheets to the main body **300** for every notification of the delivery request. In this case, a sheet conveying speed in the main body **300** is two times or higher than that in the sheet feeding unit **301**. The main body **300** separately draws sheets from the sheet feeding unit **301** so as to separate the sheets one by one to sequentially form an image.

At a time when a leading edge of the sheet delivered from the sheet feeding unit **301** reaches a conveyance roller nip disposed at a most upstream side of the main body **300**, the sheets are separately drawn by the conveyance roller of the main body **300** one by one and discharged. The sheet feeding unit **301** completes the feeding operation at a time when the number of overlaid sheets requested by the main body **300** is fed and conveyed. The sheet feeding unit **301** completes the operation and enters a stand-by state after separately drawing and discharging the overlaid sheet group by the main body **300**.

The sheet conveyed by the suction conveyance mechanism **51** of the first sheet feeding device **311** is fed to the main body **300** through a first conveyance part **317** and a joint conveyance part **319**. The sheet conveyed by the suction conveyance mechanism **51** of the second sheet feeding device **312** is fed to the main body **300** through a lower conveyance part **318** and the joint conveyance part **319**. A conveyance stepping motor (not illustrated) is provided in each of the conveyance parts **317** to **319** and a conveyance control part (not illustrated) controls the motors to rotate the conveyance roller of each of the conveyance parts to feed the sheet. The driving of the stepping motor of each of the conveyance parts is mechanically transmitted to rotate the conveyance roller of each part to convey the sheet.

On a top surface of the sheet feeding unit **301**, an escape tray **101** that forcibly discharges a sheet in an abnormal state caused by double feeding or jam is disposed. A full load detection sensor **102** is provided to detect a full load of the sheet discharged to the escape tray **101**. Further, a plurality of displacement sensors is provided for a pair of rollers on the conveyance path of the sheet feeding unit **301** to detect the passage of the leading edge and the trailing edge of the sheet on the conveyance path.

A switching member **310** operates to select a conveyance path **390** leading to the escape tray **101** when the abnormal state of the sheet is detected and operates to select a conveyance path **381** leading to an image forming part **307** when a sheet is in a normal state. When the sheet is in the abnormal state, the sheet S is discharged to the escape tray **101**. In contrast, when the sheet is in the normal state, an image forming operation is performed based on image data received by the image forming part **307** from when the sheet is detected by an image reference sensor **305**.

A feeding operation is performed by the suction conveyance mechanisms **51** and **51** provided in each of the feeding units. A plurality of fans, which will be described below, is provided in the suction conveyance mechanisms **51** and **51** to control the sheet air-feeding. At the time of the feeding operation of the suction conveyance mechanisms **51** and **51**, the fan is controlled to blow air between the sheets S in the sheet storages **11** and **11** from the downstream side of the conveying direction.

When the sheets S are loosened, the sheets are drawn to a suction conveyance belt **21** by the suction from a suction opening **34***a*. The suction opening **34***a* is disposed inside the suction conveyance belt **21**, which has an endless belt shape as will be described below. Sheets are fed and conveyed while a part of a preceding sheet is overlaid with a part of a subsequent sheet. The suction conveyance belt **21** constitutes a suction conveyance member that draws the sheet S floated by driving of an air blowing unit **29** to convey the sheet. Details of the overlay conveying operation of the suction conveyance mechanisms **51** and **51** will be discussed below.

The main body **300** forms an image on the sheet S fed by the sheet feeding unit **301**. On the top surface of the main body **300**, the manipulation part **302** is provided to allow the user to set an operation of the image forming apparatus **300**A (image forming system). Further, a reader scanner **303** is disposed above the main body **300** to read an original image. The main body **300** includes the image forming part (sheet processing part) **307** which serves as an image forming unit. The image forming unit includes a photosensitive drum **353**, a laser scanner unit **354**, a development part **352**, and an intermediate transfer belt **355**, a fixing part **308**, and a reversing conveyance part **309**.

In the main body **300**, after receiving the sheet from the sheet feeding unit **301**, the conveyance part is controlled to convey the sheet. The image forming part **307** performs the image forming operation based on the received image data from when the image reference sensor **305** detects the sheet.

At the time of image forming operation, if the image reference sensor **305** detects the sheet, a semiconductor laser (not illustrated) in the laser scanner unit **354** is controlled to be turned on/off and also the intensity of the semiconductor laser is controlled. Further, the scanner motor that controls a polygon mirror (not illustrated) to be rotated is subjected to control. Thus, the laser light is radiated on the photosensitive drum **353** based on the image data and a latent image is formed on the photosensitive drum **353**.

Next, in the development part **352**, toner is fed from a toner bottle **351** to develop the latent image on the photosensitive drum **353** and the developed toner image is primarily transferred onto the intermediate transfer belt **355** from the photosensitive drum **353**.

Thereafter, the toner image which is transferred onto the intermediate transfer belt **355** is secondarily transferred onto the sheet to form a toner image on the sheet. Just before the secondary transfer position, a registration control part **306** is provided. The registration control part **306** corrects a skew of the sheet which is placed just before the transfer position. Further, the registration control part **306** controls the sheet conveyance to minutely adjust the toner image formed on the intermediate transfer belt **355** and a position of the leading edge of the sheet to match with each other without stopping the sheet.

Next, after the secondary transferring, the sheet is conveyed to the fixing part **308**, where heat and pressure are applied to the toner to be fixed on the sheet. Further, after the fixing, if the image is continuously printed (formed) on a rear surface of the sheet or the front and rear surfaces of the sheet are inversed, the sheet is conveyed to the reversing conveyance part **309**. Further, when the printing is completed, the sheet is conveyed to the sheet processing device **304** at the downstream side.

The sheet processing device **304** is connected to the downstream side of the image forming apparatus **300**A to perform desired processing (bending, stapling, or punching) set in the manipulation part **302** by the user on the sheet discharged from the main body **300**, on which the image is formed. Thereafter, the sheets are sequentially output to any one of discharging trays **360** as a resultant to be provided to the user. The sheet processing device **304** constitutes a sheet processing part which is a post-processing part that performs post processing on the sheet on which the image is formed.

Next, a schematic configuration of the first and second feeding devices **311** and **312** of the sheet feeding unit **301** according to an exemplary embodiment of the present invention will be described with reference to FIG. **2**. FIG. **2** is a view illustrating a configuration of the second sheet feeding device **312** in the sheet feeding unit **301**. The first sheet feeding device **311** has a configuration similar to the second sheet feeding device **312**. Therefore, the description of the configuration of the first sheet feeding device **311** may be substituted by the description of the second sheet feeding device **312**.

As illustrated in FIG. **2**, the sheet storage **11** disposed in the second sheet feeding device **312** has a tray **12** on which a plurality of sheets S is loaded (that is, the tray **12** is elevatable while supporting the sheets S). The sheet storage **11** has a trailing edge regulating plate **13** that regulates a trailing edge which is disposed at an upstream edge in a sheet feeding direction (a horizontal direction of FIG. **2**). The sheet storage **11** has a leading edge regulating plate **25** that regulates a leading edge which is disposed at a downstream edge on a sheet feeding direction of the sheet S and side edge regulating plates **14** and **16** that regulate a position of the sheet S in the width direction (a transverse direction) which is perpendicular to the sheet feeding direction. The sheet storage **11** further includes slide rails **15** and **15** provided at upstream and downstream sides in the sheet feeding direction.

A sheet trailing edge pressing part **18** is provided above the trailing edge regulating plate **13** which is slidable up and down and rotatable as a pressing member. The trailing edge regulating plate **13** presses the trailing edge of the uppermost sheet Sa to separate the sheets. The sheet trailing edge pressing part **18** also serves as a trailing edge surface detection sensor **18** which is provided in a position of the trailing edge regulating plate **13** facing a sheet surface.

The trailing edge surface detection sensor **18** is disposed in the position of the trailing edge regulating plate **13** facing the sheet surface. The trailing edge surface detection sensor **18** moves along a sheet surface in an arrow I direction (vertical direction) in FIG. **2** and detects a paper surface height when the sheet S is floated by a blowing fan **32**.

The sheet storage **11** can be pulled out from the sheet feeding unit **301** by a slide rail **15**. If the sheet storage **11** is pulled out to a front side in FIG. **2**, the tray **12** descends to a predetermined position to replenish or exchange the sheet. Further, a suction conveyance mechanism **51** of the sheet air-feeding type that separately feeds the sheets S one by one is disposed above the sheet storage **11**.

The suction conveyance mechanism **51** includes a suction conveyance part **23**, the air blowing unit **29**, and a draw roller pair **42**. The suction conveyance part **23** draws and conveys the sheet S loaded in the tray **12**. The air blowing unit **29** floats and loosens an upper portion of the sheet bundle on the tray to separate the sheets S one by one. The air blowing unit **29** blows the air toward the sheets S supported in the tray **12** to float the sheet.

The suction conveyance part **23** has the suction conveyance belt **21** that rotates in a counter-clockwise direction of FIG. **2** wound around a pair of belt driving rollers **41** and **41**. The suction conveyance belt **21** constitutes the suction conveyance member that delivers the drawn sheet S to the draw roller pair **42** at the downstream side in the sheet feeding direction (right direction in FIG. **2**) by a conveyance force. Further, the suction conveyance part **23** has a suction fan **36** that generates a negative pressure to draw the sheet S onto the suction conveyance belt **21**.

The suction conveyance part **23** is disposed inside the plurality of suction conveyance belts **21** (between the belts) in a front side and in a rear direction of FIG. **2**. The suction conveyance part **23** has a long suction duct **34** and an opening portion opening/closing mechanism **28**. The suction duct **34** is formed in the front side and -rear direction of FIG. **2** to draw the air through a suction hole (not illustrated) formed in the suction conveyance belt **21**. The opening portion opening/closing mechanism **28** opens/closes a part of a suction opening **34***a* formed in the lower part of the suction duct **34**. Further, the opening portion opening/closing mechanism **28** has a duct opening/closing member **37** that is disposed in the suction duct **34**, turns on/off a negative pressure generating operation in the suction duct **34**, and switches the suction operation of the suction conveyance belt **21** between on and off. The suction duct **34** creates a negative pressure space that draws the uppermost sheet by blowing the air in the arrow F direction of FIG. **2** by the suction fan **36**. A negative pressure generation part that has a suction opening **34***a* that applies a negative pressure for drawing the sheet to the suction conveyance belt **21** includes the suction duct **34**, the suction fan **36**, and the duct opening/closing member **37**.

The air blowing unit **29** includes a blowing nozzle **33***a* that blows the air from the leading edge to the upper portion of the sheet bundle, a separation nozzle **33***b*, a blowing fan **32**, and a blowing/separating duct **33** that sends the air from the blowing fan **32** to the nozzles **33***a* and **33***b*. The air drawn by the blowing fan **32** passes through the blowing/separating duct **33** to blow in the arrow C direction (substantially horizontal direction) by the blowing nozzle **33***a* and floats several sheets among the upper sheets of the sheets S loaded on the tray **12**. Further, the air which is drawn by the blowing fan **32** is blown in an arrow D direction by the separation nozzle **33***b* and separates the uppermost sheet Sa of the sheets floated by the blowing nozzle **33***a* from the other sheets to be drawn on the suction conveyance belt **21**.

In this configuration, if the user pulls out the sheet storage **11** to the front side of FIG. **2**, sets the sheet S, and stores the sheet storage **11** in a predetermined position, a lifter motor **19** (see FIG. **3**) is driven to cause the tray **12** to start ascending in the arrow A direction of FIG. **2**. The tray is stopped in a position where the distance from the suction conveyance belt **21** is a distance B shown in FIG. **2** to wait for a feeding signal.

The opening portion opening/closing mechanism **28** has a belt guide part **27** and a belt driving roller **203**. The belt guide part **27** is disposed near an outer side of the suction opening **34***a* at the downstream side in the sheet feeding direction. The belt driving roller **203** is disposed near the suction opening **34***a* in the belt guide part **27** to advance or retreat the opening portion opening/closing belt **201**. Further, the opening portion opening/closing mechanism **28** has an opening portion opening/closing guide **202** that is disposed in approximately a half part of the downstream side in the sheet feeding direction in the suction opening **34***a*.

The opening portion opening/closing belt **201** constitutes a shutter member that is movable between a closing position where the upstream side of the suction opening **34***a* in the sheet feeding direction is partially closed and an opening position where the suction opening **34***a* is opened. Drive of the opening portion opening/closing belt **201** is controlled to close the suction opening **34***a* from the upstream side in the sheet feeding direction.

The opening portion opening/closing guide **202** extends from a left end of the suction opening **34***a* of FIG. **2** to the center thereof. The opening portion opening/closing guide **202** can move in the horizontal direction of FIG. **2** to guide the opening portion opening/closing belt **201** while slidably supporting the front side and the rear side of the opening portion opening/closing belt **201** at two locations of the front side and the rear side of FIG. **2**.

A portion which faces the suction opening **34***a* of the belt guide part **27** is in an open state such that it communicates with an opening of the opening portion opening/closing guide **202** at the left edge of FIG. **2**. The opening portion opening/closing guide **202** communicates with an opening edge (downstream edge in the sheet feeding direction) of the belt guide part **27** at an outer periphery of the suction opening **34***a* at the belt driving roller **203** side.

The belt driving roller **203** uses a belt driving motor **200** as a driving source and positively or reversely rotates driven by the belt driving motor **200**. The belt guide part **27** is configured to have a hollow shape which is bent to have a mountain shape in the vertical direction of FIG. **2** in an inner side of the endless shaped suction conveyance belt **21**. In the uppermost portion of the mountain shape in the belt guide part **27**, a rotatable support roller **26** that guides a lower surface of the opening portion opening/closing belt **201** is disposed.

The opening portion opening/closing belt **201** is formed to have a belt shape which is not bent in a width direction (the front-rear direction of FIG. **2**) orthogonal to the longitudinal direction (the left-right direction of FIG. **2**) and has a flexibility in the longitudinal direction. The opening portion opening/closing belt **201** is slidably accommodated in the belt guide part **27** which is disposed in the endless suction conveyance belt **21** and protrudes to the arrow H direction along the opening portion opening/closing guide **202** so as to close the suction opening **34***a* from the upstream side in the sheet conveying direction

An entire length of the belt guide part **27** can entirely accommodate the opening portion opening/closing belt **201** in an opening position where the suction opening **34***a* is open. A size of the belt guide part **27** in the front-rear direction in FIG. **2** is equal to a size of the opening portion opening/closing guide **202** in the same direction. The opening portion opening/closing belt **201** is fully pulled out at the center of the suction opening **34***a* by positively rotating the belt driving roller **203** at an upper front edge of the belt guide part **27** and retreated into the belt guide part **27** from the suction opening **34***a* by reversely rotating the belt driving roller **203**.

The opening portion opening/closing belt **201** opens the suction opening **34***a* in a state where a portion from the trailing edge to the leading edge is entirely accommodated in the belt guide part **27** (see FIG. **4**), and closes approximately a half of the entire suction opening **34***a* in a state where the leading edge is fully advanced toward the suction opening **34***a* (see FIG. **5**B).

The draw roller pair **42** which is disposed at the downstream side in the sheet feeding direction of the suction conveyance belt **21** includes a driving roller and a driven roller. The driven roller contacts the driving roller to be rotatably driven. The driven roller operates in an arrow G direction of FIG. **2** according to the thickness of the sheet at the time of passage of the sheet to follow the driving roller.

The displacement sensor **43** is provided above the draw roller pair **42**. The displacement sensor **43** detects the amount of displacement from a default position of the pair of the pullout rollers **42**. The displacement amount is detected by the displacement sensor **43** according to the thickness of the sheet at the time when one sheet S is conveyed and at the time when two sheets S are conveyed, so that the leading edge and the trailing edge of the overlaid portion of the sheets are detected as the change in the displacement amount. The displacement sensor **43** constitutes a sheet detection part that detects a feeding state of the sheet S which is drawn onto the suction conveyance belt **21** and delivered.

Next, referring to FIG. **3**, a circuit block in each feeding unit of the sheet feeding devices **311** and **312** of the sheet feeding unit **301** according to an exemplary embodiment of the present invention will be described.

A dedicated ASIC **2** that drives various loads of the sheet feeding device such as a motor or a fan and the manipulation part **302** serving as a setting part which is capable of inputting sheet information such as a size, a grammage, or a surface property of the sheet are connected to a CPU **1** that controls the sheet feeding devices **311** and **312**. Further, a storage unit **3** that stores various data input in the manipulation part **302** (see FIG. **1**) or a target value or a PWM value which is used to adjust the fan and a COMP converter **5** are connected to the CPU **1**.

The CPU **1** constitutes a controlling unit that returns the opening portion opening/closing belt **201** to an opening position at a predetermined timing while closing the suction opening **34***a* following the preceding sheet Sa. The preceding sheet Sa is drawn onto the suction conveyance belt **21** and moves to the downstream side of the feeding direction while the negative pressure generation part is driven. Thus, the controlling unit controls the sheets to be drawn onto the suction conveyance belt **21** in a state where the upstream edge of the preceding sheet Sa in the feeding direction is overlaid with a downstream edge of the subsequent sheet Sb in the feeding direction by a predetermined amount.

The CPU **1** refers to data stored in the storage unit **3** and adjusts a distance B between the suction conveyance belt **21** and the uppermost sheet Sa in the sheet storage **11** (see FIG. **2**) according to the sheet information input by the user through the manipulation part **302**. Further, the CPU **1** calculates an overlaid amount of the preceding sheet Sa and the subsequent sheet Sb based on the detection result of the displacement sensor **43**. A timing of when the suction opening **34***a* is opened from the closed state by the opening portion opening/closing belt **201** is changed based on the calculation result by the CPU **1**.

The CPU **1** constitutes a determination part that determines at least one of the sheet information of the size, the grammage, and the surface property of the sheets S loaded on the tray **12**. The CPU **1** changes a timing of when the suction opening **34***a* is opened from the closed state by the opening portion opening/closing belt **201** based on the determination result of the determination part. The size, the grammage, and the surface property of the sheets S loaded on the tray **12** may be automatically determined by the CPU (determination part) **1** or determined based on the user setting.

The COMP converter **5** converts and outputs based on a detection waveform of the displacement sensor **43** an output **9** at the time of one sheet and an output **10** at the time of two sheets according to outputs of the plurality of displacement sensors **43** that detects the movement of the sheet on the conveyance path. The displacement sensor **43** is also provided on the conveyance path following the suction conveyance mechanism **51**.

A trailing edge paper surface detection sensor **18** that detects a top surface of the sheet loaded on the tray **12** and a storage opening/closing sensor **48** that detects an opened/closed state of the sheet storage **11** are connected to the ASIC **2**. Further, an upper position detecting sensor **57** and a lower position detecting sensor **55** that are positional sensors of the tray **12** in the sheet storage **11** and a sheet presence detecting sensor **56** that detects the presence of the sheet on the tray **12** are connected to the ASIC **2**. The ASIC **2** monitors outputs of the sensors.

The ASIC **2** not only issues a driving start instruction to a driving circuit that drives loads of the sheet feeding device, but also receives rotational frequency signals (FGs) of the blowing fan **32** and the suction fan **36** and performs the PWM control to rotate the fans **32** and **36** at a target rotational frequency.

A blowing fan driving circuit **22** that transmits a PWM signal output from the ASIC **2** and supplies power to the blowing fan **32** is connected to the ASIC **2**. Further, a suction fan driving circuit **40** that transmits a PWM signal output from the ASIC **2** and supplies power to the suction fan **36** is connected to the ASIC **2**. A driving circuit **39** that drives a suction solenoid **38** that opens/closes a duct opening/closing member **37** in the suction duct **34** is connected to the ASIC **2**.

A driving circuit **46** that drives a feeding motor **44** that drives the belt driving roller **41** and a driving circuit **20** that drives the lifter motor **19** that elevates the tray **12** are connected to the ASIC **2**. Further, a driving circuit **47** that drives a pullout motor **45** that drives the draw roller pair **42** and a driving circuit **3000** that drives a belt driving motor **200** that rotatably drives a belt driving roller **203** are connected to the ASIC **2**.

The feeding motor **44**, the pullout motor **45**, and the belt driving motor **200** are pulse motors and control the conveyance over a predetermined distance by the corresponding driving circuits **46**, **47**, and **3000** according to an amount of pulses supplied from the ASIC **2** based on the control of the CPU **1**. The ASIC **2** counts the amount of the pulses to control the amount of movement of the suction conveyance belt **21**, the draw roller pair **42**, and the opening portion opening/closing belt **201** based on the rotational amounts of the motors.

In the sheet feeding devices **311** and **312** according to an exemplary embodiment of the present invention, various loads of the sheet feeding device such as the motors or the fans are controlled by the CPU **1** through the dedicated ASIC **2**. However, the loads may be directly controlled by the CPU **1** without using the dedicated ASIC **2**.

Via the manipulation part (setting part) **302**, the sheet information such as the size, the grammage, and the surface property of the sheet is input from the manipulation part (setting part) **302**. The storage unit **3** stores such information and data as well as a target value or a PWM value which is used to adjust the fans. In the sheet feeding devices **311** and **312**, the storage unit **3** is directly connected to the CPU **1** that controls the sheet feeding devices to be included in the sheet feeding device.

However, the sheet information may be input and stored using a separate device in an image forming system including the sheet feeding device. For example, the manipulation part **302** and the storage unit **3** provided in the image forming apparatus may be used to input and store the sheet information. Further, instead of the sheet information input from the manipulation part **302**, sheet information which is automatically recognized within the sheet feeding device may be used.

Next, referring to FIGS. **4**A to **6**C, the suction conveyance mechanism **51** which is in process of feeding and conveying the overlaid sheet will be described. FIGS. **4**A to **6**C illustrate a series of sheet feeding operations.

In FIG. **4**A, the suction conveyance mechanism **51** is in a state where a JOB is instructed by the user and the feeding operation is started according to sheet request information from the image forming apparatus **300**A. Upper sheets Sa, Sb, and Sc among the sheets in the sheet storage **11** are loosened at regular intervals by the blowing air (arrow C) by the air blowing unit **29**. Here, the height of the sheets is managed to stably loosen the upper sheets and an air volume of the blowing air is controlled according to the detected height of the trailing edge surface detection sensor **18** disposed in the trailing edge regulating plate **13**.

A separation air in the arrow D direction in FIG. **4**A is also controlled to be synchronized with the blowing air (arrow C) by the air blowing unit **29**. The suction fan **36** of the suction conveyance mechanism **51** starts driving following the driving of the blowing fan **32** and discharges the suction air in the arrow F direction in FIG. **4**A. The duct opening/closing member **37** closes the suction opening **34***a* as illustrated in FIG. **4**A and waits for a predetermined time until the suction fan **36** becomes stable and the sheets are stably loosened by the blowing air. Further, the opening portion opening/closing belt **201** is fully accommodated within the belt guide part **27** and positioned in an outer periphery waiting position of the suction opening **34***a*. In this case, the belt driving roller **41** and the draw roller pair **42** are in a stopped state.

Continuously, in the suction conveyance mechanism **51**, after a predetermined time elapses, the duct opening/closing member **37** rotates in the arrow J direction as illustrated in FIG. **4**B to generate a negative pressure from the suction opening **34***a* for the sheet. Thus, the uppermost sheet Sa is drawn onto a portion of the suction conveyance belt **21** which faces the suction opening **34***a*. Simultaneously with the rotation of the duct opening/closing member **37** in the arrow J direction, the belt driving roller **41** is driven to start the rotation of the suction conveyance belt **21** in the arrow direction of FIG. **4**B and start the rotation of the draw roller pair **42** in the arrow direction of FIG. **4**B. Therefore, the uppermost sheet Sa drawn onto the suction conveyance belt **21** is delivered toward the right side of FIG. **4**B.

As illustrated in FIG. **5**A, the uppermost sheet Sa is continuously conveyed and the opening portion opening/closing belt **201** moves in the arrow H direction of FIG. **5**A at a time when a distance between the trailing edge of the uppermost sheet Sa and an outer periphery of the suction opening **34***a* in the upstream side in the conveying direction becomes a distance y. That is, driving of the belt driving motor **200** starts so that the opening portion opening/closing belt **201** protrudes along the opening portion opening/closing guide **202** in the arrow H direction. In this case, a moving speed Vh of the opening portion opening/closing belt **201** in the arrow H direction is equal to a feeding speed Vs of the preceding sheet Sa and controlled to show a relationship of Vh=Vs.

Continuously, the opening portion opening/closing belt **201** moves to protrude in the same direction as illustrated in FIG. **5**B. In FIG. **5**B, x is a distance from an outer periphery of the suction opening **34***a* in the downstream side in the conveying direction and is a value corresponding to the overlaid amount of the preceding sheet Sa and the subsequent sheet Sb. The distance x corresponds to 50% of the opening surface of the suction opening **34***a* and the suction conveyance belt **21** and the opening portion opening/closing belt **201** move to the position of the distance x at the same speed and maintain the speed relationship of Vh=Vs. In this case, a distance between the trailing edge of the uppermost sheet Sa and the leading edge of the opening portion opening/closing belt **201** is y.

The opening portion opening/closing belt **201** temporally stops at a position x in FIG. **5**B, and then returns to the arrow K direction in FIG. **5**B when the belt driving motor **200** reversely drives the belt. In this case, the returning speed is defined by Vk.

Next, as illustrated in FIG. **6**A, the trailing edge of the uppermost sheet Sa which is continuously delivered is conveyed by a distance corresponding to y to the position of x. In the meantime, the opening portion opening/closing belt **201** returns to the outer periphery of the suction opening **34***a* at a movement speed Vk, where all of the opening portion opening/closing belt **201** including the leading edge is accommodated within the belt guide part **27**. Here, the relationship of the movement speed Vk and the feeding speed Vs is defined by x/Vk=y/Vs.

The opening portion opening/closing belt **201** returns to the outer periphery of the suction opening **34***a* to be in an open position, so that the suction opening **34***a* is opened to the sheet Sb which is subsequent to the uppermost sheet Sa and a negative pressure is applied to the sheet Sb. Thus, a portion of the trailing edge of the uppermost sheet Sa corresponding to the distance x, and a portion of the subsequent sheet Sb corresponding to a distance x from a leading edge of the subsequent sheet Sb which abuts on the leading edge regulating plate **25** by the distance x from the upstream side to the outer periphery of the suction opening **34***a* are simultaneously drawn onto the suction conveyance belt **21**. Therefore, as illustrated in FIG. **6**A, both sheets are delivered.

As illustrated in FIG. **6**B, the preceding sheet Sa and the immediately subsequent sheet Sb are partially overlaid and delivered through the suction conveyance belt **21** and the draw roller pair **42** to be continuously conveyed to the downstream conveyance roller.

Finally, as illustrated in FIG. **6**C, the positional relationship of the sheet Sb (preceding sheet in this case) and a subsequent sheet Sc is substantially similar to the positional relationship illustrated in FIG. **5**A. Therefore, the continuous sheet feeding operations from FIG. **5**A to FIG. **6**B are repeated. Therefore, the sheet feeding conveyance operation in an imbricate state where the sheets are partially overlaid is continuously performed.

FIGS. **5**A to **6**C illustrate a series of imbricate feeding conveyance operations and the detection waveform of the displacement sensor **43** in the draw roller pair **42** is as illustrated in FIG. **7**. FIG. **7** is a timing chart illustrating an example of a detection waveform by the displacement sensor **43** in the sheet feeding device.

In this timing chart, in the horizontal axis, as passing periods of the sheets, a passing period of the uppermost sheet Sa, a passing period of the subsequent sheet Sb, and a passing period of another subsequent sheet Sc are represented. Further, in the vertical axis, output voltages at an initial position, at a time when the sheet is one, and at a time when the sheets are two are represented as an output voltage of the displacement sensor **43**.

That is, as known from the waveform example of FIG. **7**, a portion where one sheet of each of the uppermost sheet Sa, the subsequent sheet Sb, and the other subsequent sheet Sc is fed, a portion where two overlaid sheets are fed, and their changing points are detected.

A plurality of displacement sensors **43** which is provided on the conveyance path following the suction conveyance mechanism **51** also monitors the sheet conveyance state. Hereinafter, a leading edge position and a trailing edge position of another subsequent sheet are similarly detected to monitor the sheet feeding state and detect the abnormal sheet feeding.

Next, referring to FIG. **8**, control of the overlaid sheet feeding/conveyance by the CPU **1** according to the exemplary embodiment of the present invention will be described. However, this description is made by appropriately referring to the state of the suction conveyance mechanism **51** during the feeding operation in FIGS. **2**, **4**A to **6**C. FIG. **8** is a flowchart illustrating an operation of the sheet feeding device according to the exemplary embodiment.

The various sheet information (size, grammage, surface property) stored in the tray **12** by the user is input and set through the manipulation part **302** by the user to be stored in the storage unit **3**. A flow starts when the tray **12** is lifted in the arrow A direction of FIG. **2** by the lifter motor **19** and stops in a position where the distance between the suction conveyance belt **21** and the uppermost sheet Sa is B, to wait for the feeding signal.

First, in step S**1**, if the CPU **1** receives the feeding signal, the CPU **1** refers to the sheet information (sheet and JOB information) of a target feeding unit from the storage unit **3**. In step S**2**, the CPU **1** determines the feeding speed (sheet conveying speed) Vs according to the referenced sheet information, and further determines the movement speeds Vh and Vk which are opening/closing speeds of the opening portion opening/closing belt **201** and an opening portion opening/closing timer Th based on the feeding speed Vs.

The feeding speed Vs varies depending on the surface property or the grammage of the sheet. For example, if a sheet conveying speed of a general sheet which is a high-quality paper (whose grammage is 80 g/m^2) is V**1**, the speed may be reduced to V**1**×50% in a case of a thick paper that is a high-quality paper (whose grammage is 200 g/m^2). Further, in a case of a coated paper whose sheet surface is processed like a coated paper (whose grammage is 200 g/m^2), the speed is reduced to V**1**×33%. This value is determined by the result of study in the image forming apparatus **300**A in advance and stored in the storage unit **3** in advance.

The movement speeds Vh and Vk of the opening portion opening/closing belt **201** according to the above value are described with reference to FIGS. **4**A to **6**C.

The opening portion opening/closing timer Th is calculated based on a length S of the sheet size of the sheet information in the conveying direction and calculated and determined by the following equation:

$$Th=\{S-(2x+y+z)\}/Vs$$

In this equation, z indicates a conveyance distance from the outer periphery of the suction opening **34***a* in FIG. **2** to a detection position of the displacement sensor **43** disposed in the draw roller pair **42**.

Next, in step S**3**, the CPU **1** inputs a control signal into the suction fan driving circuit **40** in the target feeding unit to drive the suction fan **36**. Similarly, in step S**4**, the CPU **1** inputs a control signal to the blowing fan driving circuit **22** and drives the blowing fan **32** to start to blow the air.

In step S**5**, the CPU **1** waits for a predetermined time until the distance between the surface position of the uppermost sheet Sa and the suction conveyance belt **21** is a B' position of FIG. **4**A by the air blowing and the stable surface position is detected by the trailing edge paper surface detection sensor **18**. The state of the suction conveyance mechanism **51** at this time is as illustrated in FIG. **4**A.

Continuously, the CPU **1** inputs a control signal to the suction solenoid driving circuit **39** to drive the suction solenoid **38** after a predetermined time has elapsed. Thus, in step S**6**, the duct opening/closing member **37** in the suction duct **34** rotates in the arrow J direction of FIG. **4**B to open the duct opening/closing member **37**, that is, the suction opening **34***a* is opened in step S**7** and the uppermost sheet Sa is drawn by the drawing force in the arrow F direction of FIG. **4**. After opening the duct opening/closing member **37**, in step S**7**, the CPU **1** inputs a control signal to the driving circuit **46** to drive the feeding motor **44** and rotates the belt driving roller **41** in the arrow direction of FIG. **4**B and rotates the suction conveyance belt **21** in the same direction.

Next, in step S**8**, the CPU **1** inputs a control signal to the pullout motor driving circuit **47** to drive the pullout motor **45** and rotate the draw roller pair **42** in the arrow direction of FIG. **4**B, similar to the belt driving roller **41**. In steps S**7** and S**8**, the sheet Sa is conveyed to the draw roller pair **42**.

The displacement sensor **43** that is disposed at a driven roller side of the draw roller pair **42** is configured to detect the leading edge and the trailing edge of the sheet which is being conveyed by the draw roller pair **42**, from the position of the roller which is displaced according to the thickness of the sheet. In step S**9**, the CPU **1** waits until the displacement sensor **43** detects the leading edge of the sheet.

In step S**10**, if the leading edge of the sheet is detected by the displacement sensor **43**, the CPU **1** starts to count the opening portion opening/closing timer Th determined in step S**2**. In step S**11**, the sheet Sa is continuously fed and conveyed by the suction conveyance belt **21** and the draw roller pair **42** until the opening portion opening/closing timer Th reaches the Th determined in step S**2**. In other words, in step S**11**, the opening portion opening/closing timer Th is continuously counted up and the CPU **1** waits until the timer reaches Th. The state of the suction conveyance mechanism **51** at this time is as illustrated in FIG. **5**A.

At the time when the count value of the opening portion opening/closing timer Th reaches Th, the CPU **1** determines that the sheet reaching position is in a state illustrated in FIG. **5**A. In step S**12**, in order to protrude the opening portion opening/closing belt **201** from the initial position of the outer periphery of the suction opening **34***a* at a speed Vh, the CPU **1** control the driving circuit **3000** through the ASIC **2** to positively rotate the belt driving motor **200** at a predetermined speed. In this case, in step S**13**, the amount of pulses which are applied to the belt driving motor **200** is controlled so that the amount of protruded opening portion opening/closing belt **201** reaches a target value illustrated in FIG. **5**B.

In step S**14**, at a timing of when the amount of the protruded opening portion opening/closing belt **201** reaches a position (closed position) illustrated in FIG. **5**B, the belt driving motor **200** is stopped and the movement of the opening portion opening/closing belt **201** is temporally stopped. Here, it is checked whether the number of suction-conveyed sheets has reached the number of sheets requested by the JOB. If the number of sheets has not reached the number of sheets requested by the JOB (No in step S**15**), the CPU **1** proceeds to step S**16**. If the number of sheets has reached the number of sheets requested by the JOB (Yes in step S**15**), the CPU **1** proceeds to step S**18**.

If the number of sheets has not reached the number of sheets requested by the JOB, in order to draw and convey the subsequent sheet Sb, in step S**16**, the CPU **1** reversely rotates the belt driving motor **200** at a predetermined speed to return the opening portion opening/closing belt **201** which is temporally stopped to an initial position (open position) of the outer periphery of the suction opening **34***a* at the movement speed Vk. In this case, the amount of pulses which are applied to the belt driving motor **200** is controlled so that the opening portion opening/closing belt **201** reaches an initial position illustrated in FIG. **6**A from FIG. **5**B as a target value.

In step S**17**, the opening portion opening/closing belt **201** stops the movement at a timing of when the opening portion opening/closing belt **201** is in a state illustrated in FIG. **6**A. During transition in the flow from step S**16** to S**17**, the suction opening **34***a* is opened for the subsequent sheet Sb and the sheet Sb is drawn onto the suction conveyance belt **21** to be fed and conveyed.

As described above, by using the opening portion opening/closing belt which follows the preceding sheet, the CPU (controlling unit) **1** closes the suction opening **34***a*, which is opened when the preceding sheet is drawn onto the suction conveyance belt **21** to move to the downstream side of the feeding direction, based on the detection of the preceding sheet by the displacement sensor **43**. Thereafter, at a predetermined timing before the opening portion opening/closing belt **201** is separated from the preceding sheet, the CPU **1** controls the opening portion opening/closing belt **201** to move to an open position.

When the edge of the preceding sheet in the downstream side in the feeding direction is detected by the displacement sensor **43**, the CPU **1** moves the opening portion opening/closing belt **201** to a closing position at a predetermined closing timing to close the suction opening **34***a* through which the preceding sheet has passed. Therefore, the CPU **1** moves the opening portion opening/closing belt **201** to an open position at a predetermined timing while closing the suction opening **34***a*. The CPU (controlling unit) **1** sets a closing timing and a predetermined timing based on the input sheet information and moves the opening portion opening/closing belt **201** according to the closing timing and the predetermined timing to adjust a predetermined overlaid amount.

While the opening portion opening/closing belt **201** is turning back to stop, the movement amount of the preceding sheet Sa which is conveyed by the suction conveyance belt **21** corresponds to the distance y as illustrated in FIG. **5**B. Accordingly, in a state where the trailing edge of the preceding sheet Sa and the leading edge of the subsequent sheet Sb are overlaid by the distance x, the sheets are drawn and conveyed. The state of the suction conveyance mechanism **51** at this time is as illustrated in FIG. **6**A.

The preceding sheet Sa and the subsequent sheet Sb are conveyed until the preceding sheet Sa and the subsequent sheet Sb partially overlaid are in a state illustrated in FIG. **6**B and the leading edge of the subsequent sheet Sb is detected by the draw roller pair **42**. The flow returns to step S**9** and is repeated until the processing of the number of sheets requested by the JOB is completed.

Returning to step S**15**, a case when the processing of the number of sheets has reached the number of sheets requested by the JOB will be described.

In step S**14**, after stopping the protruding of the opening portion opening/closing belt **201**, if it is determined that the number of sheets reaches the number of sheets requested by the JOB (Yes in step S**15**), the CPU inputs a control signal to the suction solenoid driving circuit **39** to drive the suction solenoid **38**. By doing this, in step S**18**, the CPU **1** rotates the duct opening/closing member **37** in the suction duct **34** in a direction opposite to the arrow J direction of FIG. **4**B to close the suction opening **34***a*.

Continuously, in step S**19**, the CPU **1** inputs a control signal to the blowing fan driving circuit **22** and stops the blowing fan **32** to stop blowing the air. Similarly, in step S**20**, the CPU inputs a control signal to the suction fan driving circuit **40** and stops the suction fan **36**. In step S**21**, the CPU **1** waits until the displacement sensor **43** detects the trailing edge of the last conveyed sheet of the number requested by the JOB.

Continuously, in step S**22**, when the displacement sensor **43** detects the trailing edge of the sheet, the CPU **1** inputs a control signal to the driving circuit **46** to stop the feeding motor **44** and stops the belt driving roller **41** that drives the suction conveyance belt **21**.

In step S**23**, the CPU **1** inputs a control signal to the pullout motor driving circuit **47** to stop the pullout motor **45** and also stop the draw roller pair **42**. Further, in step S**24**, the CPU **1** inputs a control signal to the driving circuit **3000** to inversely drive the belt driving motor **200** and move back the opening portion opening/closing belt **201** from a protruded position (open position) to an initial position (closing position). In step S**25**, the CPU **1** stops the belt driving motor **200** after completely returning the opening portion opening/closing belt **201** to the initial position and completes the processing flow.

In the above-described exemplary embodiment, the overlaid amount of the preceding sheet and the subsequent sheet at the time of suction conveyance is adjusted by the CPU **1** at a timing of when the opening portion opening/closing belt **201** opens the suction opening **34***a* from the closed state soon after the displacement sensor **43** detects the leading edge of the preceding sheet. Therefore, the opening portion opening/closing belt **201** is driven to switch the suction opening **34***a* between the closing position and the open position with a simple configuration. Therefore, it is possible to draw and convey the sheets in an imbricate with a stable overlaid amount.

In other words, based on the timing corresponding to the preceding sheet Sa which is being conveyed, the opening portion opening/closing belt **201** at the open position simply returns from the temporal closing position to the open position so that the overlaid sheets may be fed with a stable overlaid amount. Therefore, it is possible to lower the feeding speed and improve the sheet conveyance efficiency without lowering the sheet productivity.

Thus, even in the image forming apparatus having a comparatively short sheet conveyance path from the position of the tray **12** to the image forming position, the sheet may be overlaid to start the conveyance from the suction conveyance unit (suction conveyance part). Therefore, it is possible to achieve high productivity while lowering the feeding speed. As a result, it is possible to feed and convey the sheet with a low power consumption and a low operation noise.

Next, a second exemplary embodiment of the present invention will be described in detail with reference to FIG. **9** which is a flowchart of an operation under the control of the CPU **1**.

An image forming system according to the secondary exemplary embodiment has a similar schematic configuration to the configuration of the first exemplary embodiment illustrated in FIG. **1**. Therefore, the description of the second exemplary embodiment will be omitted. Further, a brief configuration of sheet feeding devices **311** and **312** and a circuit block configuration view of feeding units in the sheet feeding devices **311** and **312** according to the second exemplary embodiment are similar to the configuration of the first exemplary embodiment illustrated in FIGS. **2** and **3**. Therefore, the description thereof will be omitted.

Here, steps S**1** to S**10** and S**11** to S**25** of FIG. **9** in this exemplary embodiment are substantially similar to the steps according to the first exemplary embodiment in FIG. **8** (step S**2** is slightly different). To the flow of FIG. **9**, steps S**30** to S**35** are added. Therefore, in this exemplary embodiment, steps S**30** to S**35** will be mainly described.

Specifically, in step S**2**, the CPU **1** determines the feeding speed (sheet conveying speed) Vs, movement speeds Vh and Vk which are opening speeds of the opening portion opening/closing belt **201**, an opening portion opening/closing timer Th, and a target overlapping time To based on sheet•JOB information obtained in step S**1**. The feeding speed Vs, the movement speeds Vh and Vk, and the opening portion opening/closing timer Th are the same as described in the first exemplary embodiment.

The target overlapping time refers to a time corresponding to the overlaid amount of the trailing edge of the preceding sheet and the leading edge of the subsequent sheet. In this exemplary embodiment, the target overlapping time is set to correspond to the overlaid amount of 50 mm. Steps S**3** to S**10** are similar to those in the first exemplary embodiment and thus the description thereof will be omitted.

Continuously, in step S**10**, if the leading edge of the sheet is detected by the displacement sensor **43**, the CPU **1** starts to count the opening portion opening/closing timer Th determined in step S**2**. The output **9** for one sheet and the output **10** for two sheets of the COMP converter **5** that converts the output of the displacement sensor **43** are input to the ASIC **2** and the output results are monitored by the CPU **1**.

When the displacement by the leading edge of the sheet is detected by the displacement sensor **43** in step S**10**, if the displacement is the change point (referred to as ON) of the output **10** for two sheets from one sheet to two sheets (Yes in step S**30**), in step S**31**, the CPU **1** starts to count an overlapping time timer Ts. In step S**32**, the CPU **1** waits until the change point (referred to as OFF) of the output **10** for two sheets from two sheets to one sheet is detected.

The CPU **1** stops counting the overlapping time timer Ts at a timing of when OFF of the output **10** for two sheets is detected and determines the overlapping time timer Ts. After determining the overlapping time timer Ts, in step S**33**, the CPU **1** stores the determined Ts value in the storage unit **3** and then clears the overlapping time timer Ts to be **0**. The determined overlapping time timer Tx is an overlapping time corresponding to a distance and a time corresponding to an amount of overlaid sheets when the sheets are actually conveyed. In order to compare the determined overlapping time timer Tx with a target overlapping time To, in step S**34**, the CPU **1** reads the overlapping time timer from the storage unit **3** to compare the overlapping time timer with the target overlapping time. The comparison is performed as follows:

$\alpha=(To-Ts)$, and a correction value α is determined.

If the correction value α is negative, it indicates that the conveyance of the subsequent sheet is delayed compared with the preceding sheet as to a target sequence and thus the overlaid amount is smaller than a target amount. Further, if the correction value α is positive, it indicates that the conveyance of the subsequent sheet is faster than that of the preceding sheet as to a target sequence and thus the overlaid amount is larger than the target amount.

The correction value α is determined and then stored in a predetermined address area of the storage unit **3**. In step S**35**, the CPU **1** adds the correction value α to the opening portion opening/closing timer Th determined in step S**10** to update the corrected opening portion opening/closing timer Th as follows:

$Th=Th+\alpha$. Hereinafter, the flow in step S**11** is similar to that in the first exemplary embodiment and thus the description will be omitted.

As described above, the difference of the opening portion opening/closing timer Th from the target value whenever the sheets are fed (every sheet feeding) is detected as the correction value α and the correction value α is added to the opening portion opening/closing timer Th to correct Th. Therefore, a distance y' corresponding to y in FIGS. **5**A and **5**B in the first exemplary embodiment will be as follows: $y'=y+Vs\times\alpha$. As described above, y' is corrected to appropriately change a suction timing of the subsequent sheet.

Here, if a timing of when the correction value $\alpha=0$ is y, when the correction value α is negative, $y'<y$. Therefore, the suction starting timing of the subsequent sheet becomes earlier so that the overlaid amount is increased by the amount smaller than the target value, which makes a correction to obtain an appropriate amount. In contrast, if α is positive, $y'>y$ and the suction starting timing of the subsequent sheet becomes later so that the overlaid amount is decreased by the amount larger than the target value, which makes a correction to obtain an appropriate amount.

According to the above-described exemplary embodiment, a substantially similar effect to the first exemplary embodiment is obtained. Further, the opening portion opening/closing timing is controlled to maintain the constant overlaid amount between the preceding sheet and the subsequent sheet. Therefore, it is possible to feed the sheets with the more stable overlaid amount of the sheets. Accordingly, it is possible to achieve high productivity while lowering the feeding speed and to feed and convey the sheet with a low power consumption and a low operation noise.

According to this exemplary embodiment, the correction value α is added to the opening portion opening/closing timer Th to correct the opening/closing sequence of the suction opening **34***a*. Further, the suction timing of the subsequent sheet with respect to the preceding sheet is changed to control the overlaid amount between the sheets to be constant. Therefore, if an element that feedbacks the correction value α is reflected to a movement speed Vh when the opening portion opening/closing belt **201** is closed, and a movement speed Vk when the opening portion opening/closing belt **201** is open, the similar effect may be obtained. Further, it is obvious that the similar effect may be obtained even when the feeding speed (sheet conveying speed) Vs is changed.

Further, in this exemplary embodiment, the opening portion opening/closing belt **201** is moved from the upstream side in the conveying direction maintaining a certain distance y from the trailing edge of the preceding sheet Sa while it is synchronized with the feeding speed Vs. However, when the suction opening **34***a* is closed from the direction perpendicular to the conveying direction in an amount equivalent to the suction opening **34***a* closed by the opening portion opening/closing belt **201** illustrated in FIG. **5**B or applying of the suction force in a corresponding portion of the suction opening **34***a* is stopped by the shutter, the similar effect may also be obtained. However, this is limited to a case when a degree of the suction force in the corresponding portion of the suction opening **34***a* does not cause stable drawing of the subsequent sheet.

In the first and second exemplary embodiments, an example in which the present invention is applied to the sheet feeding devices **311** and **312** that supply the sheet to the image forming unit is described. However, the present invention is not limited thereto. For example, the present invention may be applied to an inserter. In this case, a sheet on which an image is formed may be supplied to the sheet processing device **304** (sheet processing part) or another sheet may be supplied between sheets which are disposed between the image forming unit and the sheet processing device **304** and conveyed with an image formed thereon by the image forming unit.

While the present invention has been described with reference to exemplary embodiments, it is to be understood that the invention is not limited to the disclosed exemplary embodiments. The scope of the following claims is to be accorded the broadest interpretation so as to encompass all modifications, equivalent structures, and functions.

This application claims priority from Japanese Patent Application No. 2012-018449 filed Jan. 31, 2012, which is hereby incorporated by reference herein in its entirety.

What is claimed is:

1. A sheet feeding device, comprising:

an elevatable tray that supports a sheet;

an air blowing unit that blows air toward the sheet supported by the tray to float the sheet;

a suction conveyance member that draws and conveys the sheet floated by driving the air blowing unit;

a negative pressure generation part that has a suction opening that applies a negative pressure for sheet suction to the suction conveyance member;

a shutter member that moves between a closing position where the suction opening in an upstream side in a sheet feeding direction is partially closed and an open position where the suction opening is opened; and

a controlling unit that is, in a driving state of the negative pressure generation part, configured to control the shutter member to follow a preceding sheet that is drawn onto the suction conveyance member, to move to a downstream side in the feeding direction to close the suction opening, and return to the open position at a predetermined timing to draw the sheets onto the suction conveyance member in a state where an upstream edge of the preceding sheet in the feeding direction and a downstream edge of a subsequent sheet in the feeding direction are overlaid by a predetermined amount.

2. The sheet feeding device according to claim **1**, further comprising:

a sheet detection part that detects a feeding state of a sheet that is drawn onto the suction conveyance member and delivered from the sheet feeding device to a sheet processing part;

wherein the controlling unit moves the shutter member to the open position at the predetermined timing before the shutter member is separated from the preceding sheet after the shutter member following the preceding sheet closes the suction opening that is opened when the preceding sheet is drawn onto the suction conveyance member to move to the downstream side of the feeding direction based on detection of the preceding sheet by the sheet detection part.

3. The sheet feeding device according to claim **2**, wherein, when the downstream edge of the preceding sheet in the feeding direction is detected by the sheet detection part, the controlling unit moves the shutter member to the open position at the predetermined timing while moving the shutter member to the closing position to close the suction opening through which the preceding sheet has passed at a predetermined closing timing.

4. The sheet feeding device according to claim **3**, wherein the controlling unit sets the closing timing and the predetermined timing based on input sheet information and moves the shutter member according to the closing timing and the predetermined timing to adjust the predetermined amount when the sheets are overlaid.

5. The sheet feeding device according to claim **1**, wherein the suction conveyance member is an endless suction conveyance belt, the negative pressure generation part has a suction duct disposed inside the suction conveyance belt and a suction fan that creates negative pressure inside the suction duct, and the suction opening is disposed at a portion of the suction duct facing the suction belt.

6. The sheet feeding device according to claim **1**, wherein the shutter member is an opening portion opening/closing belt that is advanced and retreated by a belt driving roller, and the opening portion opening/closing belt moves by being guided by an opening portion opening/closing guide disposed in the suction opening.

7. The sheet feeding device according to claim **6**, wherein the opening portion opening/closing belt is movable from an upstream side to a downstream side in the suction opening.

8. An image forming apparatus, comprising:

the sheet feeding device according to claim **1**; and

a sheet processing part that performs processing on the sheet delivered from the sheet feeding device.

9. The image forming apparatus according to claim **8**, wherein the sheet processing part is an image forming unit that forms an image on the sheet.

10. The image forming apparatus according to claim **8**, wherein the sheet processing part is a post processing part that performs post processing on the sheet on which an image is formed by an image forming unit.

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